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THE DEVELOPMENT OF WATER PURIFICATION IN NEW ENGLAND.

BY ROBERT SPURR WESTON.*

[*Read October 1, 1931.*]

While artificial water purification had its beginnings in antiquity, and the ancients, notably the Egyptians, Jews and Romans, were well acquainted with the advantages of subsidence, storage, and even primitive treatment with vegetable tannins or with alum to reduce turbidity and color, the artificial purification of water by filtration really began with the installation of filters at the Chelsea Water Works (London, England) in 1829. Following this beginning, water filtration did not come into common use until after the London cholera epidemic of 1849. One associates cholera with the famous Dr. Snow who established the relation between cholera and water supply in connection with the Broad Street pump epidemic of 1848. After December 31, 1855, the filtration of all the London surface water supplies was made compulsory.

Meanwhile, in Germany, largely supplied with ground water, filters were being built for all surface waters, so that, according to Grahn,† in 1877, most of the considerable surface-water supplies in Germany had been filtered since 1858. In the work in Germany the English engineers Gill and Lindley and the German engineers Frank and Piefke served conspicuously.

Then came the Hamburg cholera epidemic of 1892 during which the protective value of filtration was so dramatically demonstrated in the neighboring city of Altona, protected by slow filters. After that, progress was rapid.

Meanwhile matters were stirring in this country. In 1865, James P. Kirkwood, Chief Engineer of the St. Louis Water Commission, was instructed to proceed to Europe to examine and report on the subject of water filtration. The result was a high grade study which was so well received that it was translated into German. Following this report, the filters at Poughkeepsie‡ and Hudson,§ N. Y., were built, and in 1879

*Consulting Engineer, Boston, Mass.
†Deutsche Vierteljahrsschrift für öffentliche Gesundheitspflege, IX, 1877, p. 108.
‡Fourth Annual Report, Water Commissioners of the city of Poughkeepsie, 1872.
§Third Report of the Water Commissioners of the city of Hudson, 1875.

Mr. J. P. Davis of Boston made estimates for slow filters for the then-existing Mystic Works. But then, as now, the people preferred "innocence to repentance" in a drinking water, and the plan was dropped in favor of supplies from the uplands.

As the century waned, — and as Pasteur, Koch and Ehrlich lived and worked — Dr. William R. Nichols of the Institute of Technology, author of a famous book on water supply, published in 1883, brought home from Europe some cultures of the newly discovered water bacteria. The connection between typhoid fever and polluted water soon became a certainty, and the art of water purification entered a new stage of development. At this time typhoid death rates of over 100 per 100 000 were common.

At the close of the century conditions in the water-supply world varied greatly. Great Britain, outside of London, depended largely upon stored water; Holland upon filtered dune water; the Latin countries and Switzerland upon water from mountain streams; while Germany made use of ground water and filtered river water.

In New England, most of the good waters were from large reservoirs, or wells, while many cities, notably those in the Merrimack Valley, were using polluted waters and typhoid fever death rates were high. However, conditions were far better than in some parts of the country where almost anything wet passed as drinking water. Even some of the safe waters possessed bad odors and tastes or were turbid or of high color.

Massachusetts was fortunate in having at this time on the staff of its Board of Health and among its water-works practitioners a group of men whose equal the writer has not met elsewhere. Because of better facilities available to the present workers in the field their accomplishments are undoubtedly greater, but the workers are not superior in ability and character. Fortunate, indeed, was the choice of Dr. Henry P. Walcott to lead the Board of Health and the Metropolitan Water Commission. It was he who was described by one of our leading water-works engineers, following a visit of Dr. Walcott to his office and works, as the most intelligent visitor in his experience, — a remarkable comment considering the fact that Dr. Walcott was, by training, a physician and not an engineer.

Contributing to the knowledge of the day were such chemists, biologists and engineers as William Ripley Nichols, Thomas M. Drown, Ellen H. Richards, Allen Hazen, Harry W. Clark, William T. Sedgwick, Edwin O. Jordan, George W. Fuller, George C. Whipple, Hiram F. Mills, Frederic P. Stearns, Desmond Fitzgerald, Dexter Brackett and X. H. Goodnough, the latter only recently leaving the service of Massachusetts to enter private practice. All these workers are well known to the readers of this paper. Many of them have been presidents of this Association.

In 1886 the Engineering Department of the Board of Health was established with F. P. Stearns as chief engineer, with the wise and intense Hiram F. Mills, the engineer member of the Board, in close touch with the work and directing its course. Soon the Lawrence experimental station

was established in a building of the Essex Company, whose chief engineer was Mr. Mills.

To read a list of the staff of this station, as well as of the staff of the Board at the State House, is to read many of the names of those who have been most prominent in water-supply and water-purification work during the past forty years.

The first published results of the work were in the Special Reports of 1890 on the purification of water and sewage, reports whose reading none should miss even today. These were accompanied by a report on the examination of water supplies, full of important data. It is unfortunate that full reports of the work of this station and that of the analytical laboratory are no longer published in full by our more frugal state government.

In 1893 the Lawrence filter,*† built under Mr. Mills' direction, was put into use. While not the first filter in America, it was the first which expressed the results of modern sanitary science. It is still in effective operation and for many years has protected a large city against water-borne diseases, although the raw-water source is one of low grade. It was in connection with this filter that Mr. Hazen made his famous study of filter sands and established methods of sand analysis which are still in use.

The Lawrence filter was an intermittent one, based upon the theory of sewage treatment by bio-chemical oxidation. It possessed oxidizing power beyond that possessed by the ordinary English continuous or slow filter. It was designed with carefully graded sand sizes to insure uniform rates of filtration. Another filter of this type was used later to remove odors and tastes due to algæ at the Ludlow‡ works supplying Springfield (now supplying Ludlow).

Slow filters of the English type were built at St. Johnsbury and at Nantucket by W. F. Codd§ before the Lawrence filter was placed in service. The St. Johnsbury filters were enlarged in 1900 and are still in use. In 1895, the filters at Milford,+ designed by Leonard Metcalf, were placed in operation and later on the plant at Springfield, designed by Allen Hazen, and the one at Athol, designed by James L. Tighe. Some time later the water supplying the Springfield filters was treated with sulphate of alumina in order to produce an effluent of better appearance and lower color. This practice has been continued.

Slow filters have been built at Hartford, Farmington and for parts of Norwalk and New Haven, Conn., at Keene, N. H. and at Gardiner and Bar Harbor, Me. Filters of the same type, with aërators added, were placed in service at Wakefield, Mass. in 1929. This type of filter still has its place, particularly for the removal of odors and tastes and for

*H. F. Mills. This Journal IX, 44.
†H. W. Clark. This Journal XII, 231.
‡This Journal XXI, 284 and XXIII, 289.
§This Journal VIII, 171.
+F. L. Northrop. This Journal X, 262.

deferrization and demanganization, where high rates of filtration are practicable.

Mr. H. W. Clark has shown how ferric hydrate may be used with slow filters to increase their efficiency for color removal.

As advised by Mr. Hazen, all the early filters were uncovered but experience proved that it was wise to cover filters even so far south as Virginia.

For covering filters the groined arch roof was developed. The first use of it in this country was made at Ashland,* Wisconsin, in 1895 and at Somersworth, N. H. in 1896, by Mr. William Wheeler, a member of this Association since 1899. Mr. Wheeler invented the Wheeler bottom for rapid filters and has been an ingenious designer, builder and operator of water works.

Mechanical filters probably originated in industrial plants. The S. D. Warren Company, paper makers of Cumberland, Me., made these filters and some of the so-called Warren filters are still in service, notably in the plant at Biddeford-Saco, Me., built in 1896.

According to the most reliable records the first municipal mechanical filter was placed in operation at Somerville, N. J., in 1885. The design of this filter was based upon the Hyatt patents, regarding the use of applied chemicals. Several companies arose, and plants, particularly those of pressure type, multiplied. One of the first was the large pressure plant at Atlanta, Ga., installed in 1887. The oldest mechanical filter in the writer's experience was a Blessing filter made by the Albany Steam Trap Co. in Albany and installed at Athol, in 1887.

At a paper mill on the Ware River are three Hyatt "Re-wash" filters dating from perhaps the late '80's. These curious devices have two compartments, one of which, the lower one, is used for filtering. The sand layer is washed by ejecting it into the second compartment from which the dirty water overflows, and the sand is returned to the filtering compartment beneath.

A filter designed by the local water company was built at Newport, R. I., shortly before 1900, and the Warren filters were installed at Augusta, Me., and New York filters at Greenwich, Conn., in 1887. Similar plants were installed elsewhere. Most of these filters, with the exception of the Warren, and later Jewell filters, were of the pressure type. The first attempt to design a mechanical filter on a scientific basis followed experiments by Mr. Edmund B. Weston† at Providence in 1893 and 1894, using the colored and polluted Pawtuxet River water. These experiments were followed by the installation of the East Providence plant on the Ten-Mile river in 1899, a plant which, with additions and improvements, is still in successful operation.

It is interesting to note that at almost the same time, open, slow

*This Journal XI, 301.
†This Journal, XIV, 333.

filters designed by Allen Hazen were installed at the Pettaconset works of Providence. Later on, ice interfering with their operation, they were covered.

Extensive experiments by the Louisville (Kentucky) Water Co., under the direction of Mr. George W. Fuller, in 1895–1897, at Cincinnati in 1898, at Pittsburgh in 1897–1898, and at Lorain, Ohio, by Allen Hazen and others in 1902 and at New Orleans by the writer, in 1900–1901, as well as at Philadelphia and elsewhere laid the foundation for modern, rapid water-purification plants. The most important results of these experiments were the showing of the values of various chemical coagulants and of the necessity for the proper proportioning of chemicals and water, for sufficient time for coagulation, for proper regulation of rates of filtration, for thorough washing of sand layers and for proper selection of filter sand.

At the time of the Louisville experiments, gravity filters, of which the Jewell and the Warren filters were the best examples, were displacing the pressure type, and the trend was toward rectangular units built of concrete, the use of which units having been made possible both by the use of compressed air to agitate the sand during washing, as at Little Falls, N. J., and by the use of wash water at more than twice the prevailing velocities as developed at Cincinnati* by Mr. J. W. Ellms. The first large filter plant was the Little Falls, N. J., plant.† This was placed in service in 1902. The first modern plant in New England was constructed at Burlington, Vt., in 1908. This was designed by Mr. Fuller and based upon his experience at Louisville and Cincinnati. Strangely enough, several mechanical filter plants were finished before the one at Louisville. Providence adopted slow filters, as did Hartford, when the time for purification came. At Hartford improved devices for cleaning layers of filter sand and for handling the sand were added, thereby giving the plant some of the convenience of a rapid filter. The Hartford filters, recently enlarged, are still giving good service with a nearly clear water of moderate color.

Among rapid filters now in operation are those at Greenwich, Putnam, Simsbury, Bethel, Meriden, South Manchester and Wallingford, Conn.; at Providence, Warren-Bristol, East Greenwich, East Providence, Phillipsdale and Newport, R. I.; at Cambridge and Reading (deferrization), Mass.; at Exeter, Newmarket and Lebanon, N. H.; at Kennebunk, Biddeford-Saco, Springvale, Oldtown, Calais, Mechanic Falls, Millinocket, Wisconsset, Woodland, North Berwick, Bangor and Belfast, Me.‡ Perhaps the most modern examples of slow filter plants are at Hartford, Springfield and Wakefield; of rapid ones at Providence and at Cambridge. All are used for sanitary protection and to remove color, odors and tastes. Quite recently the Providence plant has had to adopt special treatment for the

*"Water Purification" by J. W. Ellms. Pg. 372 — Second Edition.
†Trans. A.S.C.E., L, 394.
‡The writer is indebted to Messrs. W. J. Scott, S. DeM. Gage, Arthur D. Weston, C. P. Moat and Elmer W. Campbell for checking this information.

removal of manganese, an uncommon but troublesome constituent of water.

The current work in water purification in New England includes new mechanical filters for Chicopee and additions to the Cambridge plant. Other works are under consideration, mostly in cases where an improvement in appearance or the removal of iron or manganese is desirable.

In this brief paper the writer has endeavored to outline the steps which have led to the present stage of development of water purification, either by filtration alone or by filtration combined with aëration, chemical treatment or both. In the beginning, improvements were largely in structural design. Recently they have been largely in methods of treatment.

In connection with chemical treatment the use of chlorine must be mentioned. Over thirty years ago the disinfecting action of chlorine was known to hygienists in Europe. Sims Woodhead used chlorine to disinfect the Maidstone wells in 1897, but credit for the first application to water is usually given to A. C. Houston who, with McGowan, used it at Lincoln in 1905. This chemical, first used on a large scale in this country by Johnson at Bubbly Creek, Chicago, in 1908, is now used at hundreds of water works. The introduction of chlorination into New England, particularly into Massachusetts, was slow. This was because the upland waters so largely used were considered safe after storage, which was common practice; also because it was desired to avoid the use of water containing chlorine compounds, so frequently of disagreeable taste.

Recently chlorine has been used with ammonia to prolong the disinfecting action and to avoid bad tastes.

It is undoubtedly true that no single method of purification is quite so efficient as long storage. Before the general use of motor cars and the frequent migrations of urban populations to the country, particularly to regions made attractive by reservoirs, this means served to protect the public health fairly well and to produce safe water supplies. In recent years, however, the changed habits of the public have increased the hazards to public health, and the use of chlorine has necessarily increased. Other lines of defence will have to be established in future years.

Another factor which is of increasing importance is the rising standard of quality set by the water consumer. Water supplies which are highly colored, possess bad odors or tastes, contain excessive amounts of hardness, iron or manganese, or are corrosive, are in increasing disfavor, regardless of their sanitary quality, and, while New England may be some time in reaching the condition of Old England, where practically all surface supplies are purified, not only by storage but by filtration and when necessary by chemical treatment, the trend is in that direction.

OPERATING EXPERIENCES AT THE CAMBRIDGE, MASS., FILTRATION PLANT.

BY MELVILLE C. WHIPPLE* AND FRED E. SMITH.†

[*Read October 1, 1931.*]

The Cambridge Water Purification Works were put in service on April 25, 1923 and have operated continuously since that time except for one or two short periods of shut-down. There have been no additions up to the present time, but there will be shortly. The physical features of the works have been described by George A. Johnson,‡ and operation data over a period of about five years, to 1927, have been presented by M. C. Whipple§ and H. C. Chandler.§ Both of these papers appeared in this JOURNAL.

The present paper will deal with operating experiences since 1927. In addition, tables of cost and operating data will be given to supplement those recorded in 1927 for the first four years.

PRINCIPAL FEATURES OF THE WORKS.

For the benefit of those who are unfamiliar with this plant a brief description of its salient features will be given. The raw water comes principally from Stony Brook Reservoir by gravity flow, or it may be pumped from Fresh Pond which is close at hand. Entering the coagulation basin the water receives the dose of coagulant and flows in parallel through the two halves of the basin. A detention period of 2.5 hours is provided for the nominal capacity of the plant which is 14 m.g.d. Solution-feed apparatus is used for the coagulant.

After coagulation and sedimentation, the water passes to the filters of which there are ten. Each bed is 20 x 24 ft. in size, has 27 in. of sand, 9½ in. of gravel and is equipped with a Wheeler filter bottom. Wash water for the filters is supplied through a Venturi meter and rate controller and is finally discharged into the Cambridge sewers or may be pumped back to the coagulation basin.

The effluent of the filters collects in a flume from which it discharges into an aërator consisting of riffle plates studding a sloping surface. The aërated water receives lime for corrective treatment and chlorine for disinfection, the point of application being at the entrance to the clear-water basin which holds 3.5 m.g.

The plant has been free from difficulties due to structural defects in

*Assistant Professor of Sanitary Chemistry, Harvard Engineering School, Supervising Chemist, Cambridge Water Board, Cambridge, Mass.
†Chemist, Cambridge Water Purification Works, Cambridge, Mass.
‡ JOUR. N.E.W.W.A., Vol. 37, 1923, p. 339.
§ JOUR. N.E.W.W.A., Vol. 41, 1927, p. 218.

the eight years of its existence. Settlement, leakage and cracks have not been apparent, a feature that has contributed much to constant and uniform operation.

Raw Water Sources.

The quality of raw-water sources during the past four years has remained, with occasional exceptions, very similar to that previously reported. Stony Brook has furnished water more highly colored but softer than that from Fresh Pond, and a water containing greater numbers of bacteria. Fresh Pond constitutes a reserve supply, and experience has demonstrated that its water, which is subject to long storage, requires a smaller amount of alum than Stony Brook water and that it coagulates quicker.

Extremes of Color. The summer of 1928 was notable for its precipitation, and the effect of this was reflected in the color of water from the Stony Brook watershed. Swamp areas were continually flushed out into the bordering brooks to add to the organic content. During the month of July the color of the raw water at the filter plant averaged 70 p.p.m. and on July 30 reached the highest point recorded in the eight years of operation, 90 p.p.m. This water, as is always the case when freshly extracted color is present, coagulated with difficulty, giving a finely divided, slow settling floc. Alum was required for successful operation in amounts as high as 275 lb. per m.g. (1.9 grains per gal.) together with 40 lb. per m.g. of sodium aluminate. The color of the effluent averaged at this time 5 p.p.m. with a maximum of 10 p.p.m.

Similar conditions prevailed during the past summer in June and July when a maximum color of 80 p.p.m. was reached on June 21. Alum alone was employed for coagulation in amounts as high as 300 lb. per m.g. (2.1 grains per gal.). This was as large a dose of alum as has ever been used in the plant.

Fluctuations in Bacteria. The bacterial content is also one that shows wide fluctuations from time to time. Although the number of bacteria is normally only 100 per cc. and *Bact. coli* is present in 10 cc. of sample, there are times of wide departure from these figures. For instance, on February 17 of this year the bacteria in the raw water numbered 175 per cc. at 20° and 33 per cc. at 37°. *Bact. coli* was absent in 10 cc. of sample. About this time there occurred a thaw and heavy precipitation of rain that thoroughly flushed the drainage area of Stony Brook. After February 17, bacteria counts rose sharply, reaching a maximum of 22 000 at 20° on February 21, with *Bact. coli* present in 0.1 cc. There was a gradual decline in number after this for about two weeks when normal quality of water was restored.

This large increase in bacteria was marked by a rare occurrence in plant performance when *Bact. coli* was found in the effluent in two out of five 10-cc. portions on one day. The very unusual appearance of *coli* in

the effluent was due to the heavy bacterial load and to poor coagulation and inferior filter performance during cold weather. The chlorine dosage had been increased from 2.8 to 3.5 lb. per m.g., but this was evidently not great enough to accomplish thorough disinfection.

Going in the other direction, there will be days at a time when the bacteria in the raw water will number less than 100 per cc. and *Bact. coli* will be absent in 10 cc. These facts are mentioned by way of illustration that even a stored water supply is sometimes subject to great fluctuations in bacterial quality.

Experience with Synura. The most serious experience with algæ tastes and odors occurred in July of this year. On July 15 a faint cucumber taste was detected in the plant, and on the 16th was noticeable enough in the city to cause complaints. The taste practically disappeared by evening at the plant, and it was thought the trouble had passed. On the 18th it recurred in aggravated form. Microscopical examination showed that *Synura*, one of the flagellated protozoa, was present in the Stony Brook water. In numbers they were few, from 4 to 7 areal standard units per cc. being found, but these gave a distinct cucumber taste throughout the city. It was the first time this organism had been detected in the Cambridge Supply.

To combat the bad taste and odor, orders were given to shut off the Stony Brook supply and take all water from Fresh Pond. This immediately remedied the trouble. In the meantime, on July 20, copper-sulphate treatment of Stony Brook Reservoir was begun. A rather heavy dose was applied in order to be sure of results, 1 800 lb. being used in 400 m.g. of stored water, or 4.5 lb. per m.g. Treatment was completed on July 23. The following day no *Synura* were found in the water, and the cucumber taste was absent. On July 27 the water was again turned into the filter plant, one week after its use had been discontinued. This was the first experience with *Synura* in Cambridge, and we are quite in accord with previous observers that a very few standard units of this organism are capable of imparting an objectionable odor and taste.

Coagulation.

It has always been a difficult task to secure adequate coagulation and sedimentation at this plant. The principal factor in preventing successful accomplishment has been the size of the coagulation basin. This basin is often not large enough to allow thorough formation of floc, and it never allows satisfactory clarification to take place. Dozens of bottle experiments prove this point as well as plant experience. Another factor in the situation is the frequent contribution of fresh coloring matter to the raw water. Such material resists coagulation and tends to form a fine floc that settles slowly.

Use of sodium aluminate. Various means have been tried to effect

improvement. Pre-chlorination was not successful. Changes in baffling arrangements met with moderate success. Finally, the use of sodium aluminate was undertaken. This coagulant was employed from December 1926 to October 1929. It was not found to improve coagulation or the nature of the floc materially, but its use was continued for another reason. The reaction of aluminate with alum liberates no CO_2, as does the reaction of alum with the alkalinity of the water. Thus, the content of CO_2 in the treated water was reduced. Also, the excess alkali in the aluminate neutralized some CO_2. As a result, it was found under most conditions that a saving could be effected in soda ash. The latter was being used for final corrective treatment in the neutralization of CO_2.

Eventually a period of low-alum requirements caused this saving to be less apparent. The necessity of buying a new dry-feed machine for aluminate also arose, so that the use of this chemical was temporarily discontinued. It was finally abandoned when lime was substituted for soda ash in corrective treatment. There was no longer a saving.

Sludge Disposal. The sludge from the basins is by necessity discharged to the Cambridge sewer system. It was thought by some that this practice would lead to a silting up of the sewers and to possible clogging. All observations to date have failed to disclose any interference with the flow of these sewers, except that their capacity is somewhat taxed temporarily when sludge is discharged.

Solution Feed. The solution feed of alum has at times been difficult owing to deposits and growths of *Leptothrix* in the 2½-in. lead line that conveys the solution a distance of some 300 ft. At one time mechanical cleaning of this line was a frequent necessity. The practice has been largely done away with through the use of pressure flushing and the weekly application of 12 lb. of chloride of lime to the alum-solution system. By these means deposits are loosened, and *Leptothrix* is destroyed.

Filter Operation.

The ten original filters are in operation most of the time and at a rate of 130 m.g.d. per acre. The total water filtered, which includes wash water returned to the process, is 13 m.g.d. more or less. To filter this volume and allow time out for washing permits only occasionally the putting of beds out of service and then for only short periods. Opportunity is seldom given for thorough inspection and overhauling of beds.

Sand. The original sand is still in place in all the beds. It corresponds to a sea sand and came from Ipswich, Mass. Although the stock was not entirely suited to filtering purposes and was taken more from necessity than choice, it has behaved well in service. There has been some loss from washing, but no additional sand has been added since July 1926 when an average depth of 3.5 in. was replaced.

In Table 1 appear the results of mechanical sand analyses made at

different times. It will be noted that the average effective size of sand for the ten filters has increased in eight years from .38 mm. to .51 mm. Much of the increase has come about in the last two years when the load on the filters has been greater, due to the return of dirty wash-water to the process. Effective sizes now range between .48 mm. and .53 mm. The average figure for the uniformity coefficient has changed very little, the value now found being 1.54. In six beds there has been an increase in the value over that of eight years ago, in four beds a decrease.

TABLE 1. — Sizes of Sand at Different Times.

Filter No.	Effective Size in mm.			Uniformity Coefficient.		
	Feb. 1923.	July 1929.	Aug. 1931.	Feb. 1923.	July 1929.	Aug. 1931.
1	.36	.44	.50	1.53	1.36	1.44
2	.36	..	.52	1.47	...	1.61
3	.37	.44	.48	1.37	1.43	1.52
4	.37	.44	.52	1.41	1.41	1.46
5	.38	.43	.49	1.45	1.44	1.59
6	.38	.46	.51	1.45	1.54	1.53
7	.39	.46	.48	1.51	1.50	1.58
8	.39	.45	.53	1.77	1.67	1.57
9	.40	.46	.52	1.70	1.61	1.57
10	.40	.48	.52	1.70	1.52	1.54
Average	.38	.45	.51	1.53	1.50	1.54

Wheeler Bottom. The filters are equipped with the Wheeler bottom, the prime purpose of which is to provide a uniformly distributed wash. It has done this in admirable fashion. With one exception no trouble has arisen from the use of this bottom. Inspection has shown the concrete balls to have remained in place, and there has been no erosion of these balls. One bed exhibited caking and poor washing over a part of its surface. Upon digging up the filter, it was found that a number of nipples leading from the concrete boxes into the laterals were clogged with sand. The trouble was easily remedied by back-flushing. It is not known how the sand reached the nipples, but the condition is thought to date back to the original placement of sand and gravel in the bed and to be due to carelessness at that time.

Shrinkage, Cracking and Mud Balls. Pronounced shrinkage of sand from the sidewalls of the filters, which was conspicuous in the early years of operation, has not been so frequent in recent years. It is promoted by the use of long-stored water and high temperatures which aid the formation of a coarse, sticky floc that is removed at the surface of the filters. This point was discussed in the previous paper on the operation of the

Cambridge plant. When shrinkage cracks begin to form, they tend to become aggravated as time goes on due to compacting of sand, dirt and floc in the vicinity of the cracks. Ordinary washing does not effectually break up the compacted sand and mud banks.

The less frequent appearance of shrinkage cracks at Cambridge is believed to be due largely to the use of corrective measures for preventing the formation of mud banks. The treatment consists of raking along the sidewalls during washing of the filter. Long-tined, coarse rakes are used for this purpose. If the treatment is repeated at intervals of eight to ten days, mud banks and shrinkage cracks are held at a minimum.

Surface cracking of filters has not been observed in recent years. Formerly, it sometimes accompanied excessive shrinkage.

Mud balls have appeared from time to time, usually in summer, but not in troublesome numbers. They become fewer with the coming in the fall of water laden with freshly extracted color. This coagulates with a finer, less gelatinous floc.

Breaking of Filters. The most serious defect of filtration is the breaking-through of floc and dirt when losses of head exceed about 7 ft. This occurs with Stony Brook water for a few weeks during the coldest months of the year. In the opinion of the authors, the breaking-through is due to the formation of a fine floc that penetrates deeply into the bed and is later pulled through when negative heads are established. The trouble is largely obviated by pumping one-third of the raw water from Fresh Pond. As has been said, this old, stored water coagulates to form a coarser floc that is not so easily pulled through the beds.

There is no doubt that the filters in this plant are called upon for heavy duty and that they perform the bulk of the work in the removal of floc, color and bacteria. On the whole they have discharged their function in a satisfactory manner. The price of this has been a careful supervision of the washing process, attention to periodic raking and the adoption of an annual program of cleaning with caustic soda.

Caustic Treatment of Beds. This last procedure is carried out with a 1.5 per cent. solution of caustic soda (600 lb. per bed) which is allowed to remain in contact with the sand for 24 to 48 hours after which thorough washing takes place. The caustic disintegrates mud balls and loosens adhering deposits from the sand grains. It brings about a striking change in the nature of the sand; the color becomes lighter, and the shape of the grains changes from that of round to irregular particles.

Washing of Filters. Experience has dictated the necessity of thoroughly washing the filters in order that they may function well under the heavy load put upon them. A period of 2.5 to 3.5 minutes is required to remove all but traces of color. The velocity of wash water varies from 22 to 30 in. per minute according to the temperature of the water. This gives an expansion of approximately 30 per cent. Greater expansion results in some loss of sand and flooding of the rear portion of gutters.

The percentage of wash water used is higher than for many plants. This is due to the thorough washing employed and to the comparatively short runs of filters. The latter in turn are the result of the short period available for coagulation and sedimentation. The length of runs varies from 8 to 20 hours, being shortest in summer when long-stored water is used and when algæ are present. The wash water used fluctuates greatly in quantity. Reference to Table 2 will show that the minimum monthly average figure over four years was 2.4 and the maximum 8.0 per cent.

Disposition of Wash Water. One of the unusual features of the Cambridge plant is the provision for return of spent wash-water to the coagulation basin. This system was originally in operation for about a year. It had the advantage of saving half a million gallons or more of water daily, but from the operating standpoint it was without merit. The normal flow in the basin was disturbed, bacteria, tastes and odors were increased in the coagulated water, and a heavier burden of floc removal was put upon the filters. Accordingly, connection was made to the only sewer leaving the plant, the 8-in. sanitary sewer, and wash water thereafter was discharged into the Cambridge sewerage system up to the capacity of this sewer to carry it. Shortage of water in 1929 made it necessary to go back to the system of wash-water return in November. This was continued until June of this year with the former disadvantages quite apparent.

It will probably never be necessary to go back to this method of handling wash water, for a pipe-line has just been laid to a bay of Fresh Pond, making possible the discharge of all wash water into the Pond. The point is far removed from the raw-water intake, and the discharge is in 20 ft. of water. The only trouble anticipated from this new method of disposal is from possible growths of algæ which may be controlled by copper-sulphate treatment.

Chlorination.

No unusual experiences can be cited under the head of chlorination. A residual of .05 to 0.1 p.p.m. chlorine is maintained in the water delivered to the city, and this has never been productive of chlorinous tastes. Filtered water is now pumped directly to the mains against the head of Payson Park Reservoir and not, as formerly, into this reservoir and thence to the city. A single vacuum-type chlorinator has been in use at the plant continuously for over eight years, with emergency equipment at the city pumping station. No major repairs have been necessary on this chlorinator until very recently. Its performance and record have been entirely satisfactory.

Corrective Treatment.

Corrective treatment for corrosive qualities has been practised since the first six months of operation, during which time "red-water troubles"

TABLE 2. — SUMMARY OF OPERATION AND CHEMICAL TREATMENT.
(Compiled from Monthly Averages of Daily Results.)

Values.	Volumes of Water in Million Gallons.						Wash Water. (Per Cent.)	Length of Runs. (Hours.)	Water Filtered m.g.d. per acre.		Average Loss of Head in Feet.		Electricity in K.W.H.	Chemicals, Lb. per Million Gal.			
	From Stony Brook.	From Fresh Pond.	Total Filtered.	Sent to City.	Wash Water.												
					Pumped.	Used.			Yield.	Rate.	Initial.	Final.		Alum.	Sod. Alum.	Soda.	Chlorine.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
April 1927 to March 1928.																	
Average	11.67	0.94	12.69	12.16	0.54	0.44	3.2	14.7	115	130	0.8	7.8	263	176	41	77	2.4
Maximum	12.58	4.50	13.18	12.78	0.75	0.60	4.3	20.4	123	130	1.1	8.3	587	261	68	111	3.0
Minimum	8.56	0.33	12.15	11.54	0.40	0.34	2.4	10.4	110	130	0.5	7.7	148	87	25	33	1.6
April 1928 to March 1929.																	
Average	11.47	1.47	13.10	12.38	0.68	0.57	4.1	13.8	119	130	0.9	8.5	333	162	36	91	2.8
Maximum	13.31	4.60	13.66	13.01	1.06	0.89	6.4	19.1	123	130	1.1	8.7	780	249	43	148	3.0
Minimum	8.80	0	12.24	11.55	0.49	0.44	3.1	8.6	111	130	0.8	8.2	181	92	28	62	2.5
April 1929 to March 1930.																	
Average	11.70	1.31	13.38	12.54	0.81	0.68	4.8	11.6	122	130	0.9	8.6	368	140	23	74	2.6
Maximum	13.63	3.97	13.80	13.08	1.06	0.89	6.1	14.8	125	130	1.2	9.0	620	189	29	119	2.9
Minimum	8.65	0.01	12.25	12.14	0.59	0.48	3.5	8.2	111	130	0.7	7.0	185	95	17	27	2.4
April 1930 to March 1931.																Lime	
Average	10.07	2.28	13.21	12.30	0.88	0.74	5.6	12.1	120	130	0.8	8.2	540	164	..	82	2.9
Maximum	12.71	5.02	13.67	12.88	1.22	1.03	8.0	16.1	124	130	1.1	8.6	780	227	..	126	3.2
Minimum	6.86	0.38	12.77	11.83	0.66	0.52	3.8	8.6	116	130	0.7	7.2	268	91	..	44	2.6

TABLE 3. — SUMMARY OF PHYSICAL, CHEMICAL AND BACTERIOLOGICAL ANALYSES.
(Compiled from Monthly averages of Daily Results.)

Values.	Temp. F° Eff.	Turbidity. p.p.m.			Color. p.p.m.			Alkalinity. p.p.m.			Carbon Dioxide. p.p.m.			pH Value.			Bacteria per c.c.								Bacterium Coli. per 100 c.c.			
																	Gelatine at 20° C.				Agar at 37° C.							
		Raw.	Coag.	Eff.	Raw.	Coag.	Eff.	Raw.	Coag.	Eff.	Raw.	Coag.	Eff.	Raw.	Coag.	Eff.	Raw.	Coag.	Filt.	Eff.	Raw.	Coag.	Filt.	Eff.	Raw.	Coag.	Filt.	Eff.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
April 1927 to March 1928.																												
Average...	53	2	2	−1	49	39	8	16.0	10.0	17.5	4.0	11.0	3.0	..	..	..	278	209	79	2	112	52	8	2	12	11	1.0	0.17
Maximum..	65	3	4	−1	74	59	16	17.5	13.5	20.5	6.5	18.0	4.5	..	..	..	870	720	152	9	253	133	20	4	26	30	4.6	0.4
Minimum..	39	1	5	0	30	25	2	11.0	5.0	14.0	3.0	6.5	2.5	..	..	..	95	70	9	0	43	10	2	1	4	0	0	0
April 1928 to March 1929.																												
Average...	52	2	2	−1	45	33	5	18.0	13.0	22.0	2.0	..	1.0	6.80	..	7.0	230	140	70	2	80	48	10	2	22	12	0.8	0.02
Maximum..	70	3	4	−1	70	47	7	21.5	17.5	28.0	5.5	..	2.5	7.10	..	7.20	700	240	190	4	175	100	45	3	51	34	1.6	0.16
Minimum..	38	1	2	0	31	26	3	14.0	7.0	17.5	0.5	..	0.5	6.65	..	6.90	104	35	10	0	45	12	2	1	8	2	0	0
April 1929 to March 1930.																												
Average...	53	2	2	0	29	24	3	16.0	11.0	19.0	2.0	..	1.5	6.85	..	7.00	435	450	106	14	102	53	5	2	19.9	12.0	0.33	0.05
Maximum..	70	2	3	−1	51	34	5	20.0	13.0	22.5	4.0	..	2.0	7.10	..	7.35	1 880	2 540	265	105	320	165	10	8	43.0	30.0	0.80	0.5
Minimum..	39	1	2	0	18	14	1	15.0	8.5	16.0	1.0	..	0.5	6.70	..	6.90	115	65	18	1	27	12	1	1	3.5	1.2	0	0
April 1930 to March 1931.																												
Average...	55	2	3	0	27	27	3	19.0	10.0	22.0	3.0	10.0	0	7.00	..	8.20	655	640	182	16	147	101	27	2	22.6	8.1	0.07	0.02
Maximum..	73	3	3	0	40	40	5	21.0	14.5	25.0	5.0	12.5	0	7.20	..	8.40	4 150	4 030	450	82	448	245	147	7	118.0	21.2	0.42	0.25
Minimum..	38	1	2	0	15	15	1	16.0	6.5	17.5	2.0	7.0	0	6.80	..	8.10	150	95	20	1	46	22	1	1	1.90	1.20	0	0

were manifest. Soda ash was added to the aërated effluent for 6½ years. The resulting water carried a CO_2 content of 1 to 2 p.p.m. in the later years of this treatment, and the pH value was close to 7.0. The hardness of the water was not increased by addition of soda ash, substances forming incrusting boiler-scale were kept at a minimum, and red-water troubles were not pronounced. On the whole, it was our feeling that a fairly satisfactory program of correction was being carried out.

In 1929 interested parties made a survey of the condition of brass piping in some of the buildings of Harvard University. The findings indicated that corrosion of this material was going on at a rapid rate and that some piping showed serious deterioration after a period of three years. It was not plain just why the water of the city should promote this rapid action, but the decision was made to go farther with the corrective treatment and to use lime instead of soda ash. It was thought that the householders would prefer a somewhat harder water with slightly increased soap bills to the inconvenient and costly procedure of having piping renewed in their houses.

The Water Board purchased a Wallace & Tiernan dry-feed machine, and lime treatment of the aërated effluent was begun in March 1930. The point of application is the entrance to the clear-water basin, the dry-feed machine being set on the floor above. This arrangement makes an injector unnecessary, but calls for use of a water spray to overcome the draft of air in the down-pipe.

The amount of lime added varies with the CO_2 content of the water, being from 50 to 125 lb. per m.g. Routine practice at the plant calls for an excess of lime over CO_2 requirements. In other words, all the CO_2 is neutralized, and there remains a normal carbonate alkalinity of 5 to 10 p.p.m. The pH value of the final effluent is held close to 8.4. At this pH value the water does not absorb, by test, further amounts of normal carbonate and, therefore, should promote in pipes the formation of protective films of carbonate. The total hardness is now about 45 as compared with 30 p.p.m. when soda ash was used.

It is too early to judge finally the results of lime treatment of this water, but such indications as we have lead to the belief that increased protection is being given and that the corrosion of brass, particularly, is going on at a lessened rate.

Tables.

Tables of analysis, operation and cost constitute a part of this paper and represent an extension of the data supplied in the paper that was published in this Journal in 1927. The reader is referred to these tables for a more intimate knowledge of the workings of a plant that is believed to have been successful in producing a water acceptable to its consumers and possessed of qualities that meet present-day standards.

Cost of Operation.

Figures of cost are always of special interest to those in charge of filter plants and are given in Tables 4 and 5. We have arranged Table 5 to show the five principal items of expense and have presented total costs and costs per million gallons. No part of the fixed charges of the works is included.

Table 4. — Cost of Chemical Treatment.

Year.	Volume of Water M.G.		Chemicals Used, Tons.				Cost per Ton.			
	Coagulated.	Corrected and Chlorinated.	Alum.	Soda or Lime.	Chlorine.	Aluminate.	Alum.	Soda or Lime.	Chlorine.	Aluminate.
1	2	3	4	5	6	7	8	9	10	11
1927–28	4 615	4 453	404.90	171.72[1]	5.209	91.73	$31.00	$32.40[1]	$150	$80.00
1928–29[3]	4 720	4 512	382.10	207.00[1]	6.200	77.30	31.00	32.40[1]	150	80.00
1929–30[4]	4 723	4 473	330.48	149.75[1]	6.019	28.38	31.00	31.40[1]	160	85.00
				10.77[2]				12.80[2]		
1930–31	4 787	4 499	390.61	2.12[1]	6.496	..	31.00	31.40[1]	160	..
				184.48[2]			25.00	12.60[2]		

Year.	Total Cost.				Combined Total Cost.	Cost per Million Gal.				Combined Total Cost per Million gal.
	Alum.	Soda or Lime.	Chlorine.	Aluminate.		Alum.	Soda or Lime.	Chlorine.	Aluminate.	
1	12	13	14	15	16	17	18	19	20	21
1927–28	$12 550	$5 560	$780	$7 340	$26 230	$2.72	$1.25	$0.18	$1.59	$5.74
1928–29[3]	11 830	6 710	930	6 180	25 650	2.51	1.48	0.21	1.42	5.62
1929–30[4]	10 250	4 838	965	2 410	18 463	2.17	1.08	0.22	1.03	4.50
1930–31	10 000	2 392	1 040	..	13 432	2.09	0.53	0.23	..	2.85

1. Soda Figures.
2. Lime Figures.
3. Aluminate used 11 months.
4. Aluminate used 7 months.

It will be noted that, for the four years involved, the total cost of operation has decreased from about $52 000 to $43 000 and the cost per million gallons from $11.29 to $9.07. The decreasing charge for chemicals

accounts for the reduction. Close supervision has marked the use of chemicals during these four years, but the major part of the reduction is due to the use of lime in place of soda ash, starting in March 1930. Other items than chemicals show fairly constant costs with the exception of Power, Light and Fuel which increased in 1931. That year marked the greatest pumpage of raw water from Fresh Pond, the procedure involving charges for power.

Filter Operators.

A recital of operating experience may well include some mention of human factors involved. The Cambridge plant has been very fortunate in the high character of service rendered by its operators and they deserve no small measure of credit for whatever success has attended the running of the plant. There has been a very small turnover of individuals in connection with these positions. Of eight operators, two have been in service since the building of the works and none has been employed for less than three years.

Additions to the Works.

The need of securing more water and of having enlarged purification facilities has recently made it necessary for the Water Board to ask for an appropriation of $800,000 for improvements. This has been granted, and preliminary work is now going on. The following items will be undertaken:

1. New intake and pumps at Fresh Pond.
2. New filter beds at the present plant.
3. Additional pipe capacity from Stony Brook.
4. New mains in the distribution system.
5. New meters in certain districts to determine the effect upon consumption and upon receipts for water.

The first two items affect directly the purification works. The new intake and pumps at Fresh Pond will make possible the taking of water down to a depth of about 30 ft., some 22 ft. deeper than at present, thus making available an additional volume of 800 m.g.

The new filters will be six in number, giving a total of 16 beds. They will be placed in an extension of the present building, at a right angle to the central portion. Wheeler bottoms will be a part of the filter equipment.

TABLE 5. — OPERATING COST DATA.

Item.	Total Cost. Year Ending March 31.				Cost per Million gal. Treated. Year Ending March 31.			
	1928.	1929.	1930.	1931.	1928.	1929.	1930.	1931.
Chemicals	$26 230.00	$25 650.00	$18 463.00	$13 432.00	$5.67	$5.44	$3.90	$2.81
Labor, Operators	15 498.22	15 725.72	15 211.10	16 156.73	3.36	3.34	3.22	3.37
Laboratory, Chemists, Supplies	3 915.78	4 073.12	4 220.03	4 158.98	0.85	0.86	0.89	0.87
Power, Light, Fuel	4 630.74	4 555.08	5 180.06	7 019.10	1.00	0.97	1.10	1.46
Equipment, Service and Supplies	1 886.93	575.40	1 770.90	2 680.79	0.41	0.12	0.38	0.56
Totals	$52 161.67	$50 579.32	$44 845.09	$43 447.60	$11.29	$10.73	$9.49	$9.07
Million gal. Treated	4 615	4 720	4 723	4 787	...	...	...	...

FIVE YEARS' WATER PURIFICATION AT PROVIDENCE.

BY ELWOOD L. BEAN.*

[*Read October 1, 1931.*]

In 1926, a group of seven papers was published in this JOURNAL† describing various phases of the development of the Providence water supply, construction of the dam, purification works, tunnel and aqueduct. In 1927, furthermore, a paper describing the experiences and results of a year's operation of the new supply appeared in this JOURNAL.‡

The impounding reservoir (Scituate Reservoir) of the Providence Supply, has a storage capacity of 37 billion gal., a flowage area of 5.6 sq. miles, with an average depth of 32 ft. and a maximum depth from flow line of about 85 ft. The catchment area of the reservoir comprises 92.8 sq. miles, of which slightly over one-half is wooded or brushy area and 25 per cent. is owned by the city. A minimum quantity of water is discharged from the reservoir daily to maintain a definite streamflow in the river below the dam. This water is drawn, as required by legislative act, from near the surface, and any excess water is discharged in the same way. The water is passed through a 2 200-h.p. hydro-electric turbine-generator, and the current not required by the Water Works is sold to the local power company under a 10-year contract.

The flow line of the reservoir is at El. 284.0, and the bottom elevation is about 200. Water may be drawn for the purification process from El. 213 to 220 or El. 235 to 240 or at any desired point between El. 252 and 277. The surface elevation of water for the five years during which the Works have been in service is shown at the top of Figure 1. It will be noted that the reservoir was first filled in November 1927, fourteen months after the purification plant was started. It then remained practically full until the drought of late 1929 and 1930, which caused it to drop about 20 ft. This occurred under an average total draft of about 70 m.g.d., about 25 m.g.d. being used for the city's consumption, the remainder being discharged down the river.

RAW WATER.

From the time of starting the plant on September 30, 1926, until February 1, 1930, raw water was drawn from the intermediate intake at El. 235–240, except for a period of five weeks in November and December 1928, when work on gates at the hydro-electric plant made it expedient to draw from the upper intake. Since February 1, 1930 the upper intake

*Chemist, Water Purification Works, Providence, R. I.
†JOUR. N.E.W.W.A., Vol. 40, 1926, p. 477.
‡JOUR. N.E.W.W.A., Vol. 41, 1927, p. 399.

has been in use the major part of the time. A water ordinarily good in quality is obtainable from near the surface at all seasons of the year except during the overturn season in the fall, but use of warm surface water during the summer stimulates biological action in the sludge precipitated in the coagulation basins, resulting in the forming of gases which lift the sludge to the surface. For this reason, it has been necessary to use a lower-level water during hot weather. Tests have shown repeatedly that

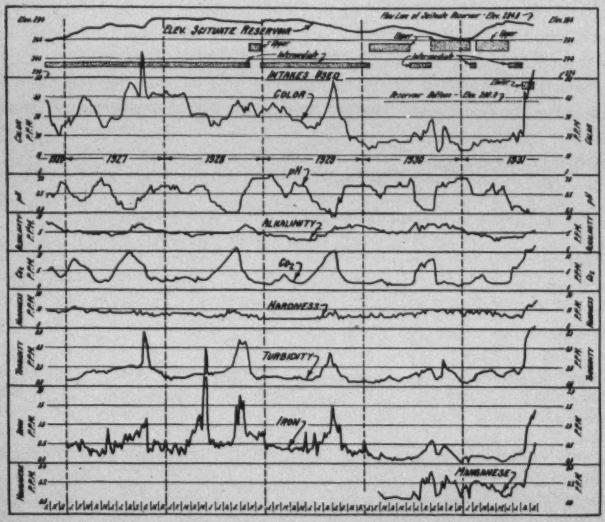

FIG. 1. — RAW-WATER CHARACTERISTICS.

the intermediate-level water is more easily coagulated, and since water of lower temperature is delivered to the city taps there are two advantages in using the intermediate-level intake in summer. Microscopic organisms have not been numerous in the surface water during the past two years. Their presence in earlier years might have caused trouble if surface water had been drawn in summer; in fact, during the first three weeks of operation of the plant in 1926, *Anabæna*, *Cylindrospermum* and other *cyanophyceæ* sealed up the filters and presented difficult operating problems.

The quality of raw water available from a deep reservoir is never constant. The Scituate Reservoir is no exception to the rule, and the raw water varies with the seasons and, though the variations are gradually lessening, there is no reason to suppose that a stable condition will ever be reached any more than has been the case in old reservoirs, even when they have been stripped. Figure 1 shows the weekly average characteris-

tics of the raw water drawn during the five years, also the elevation of intake used and its relation to the water surface and the bottom of the reservoir. Reference to this figure shows that during the period of July 1 to September 15 the intermediate intake was used in each of the years from 1927 to 1930, and that the peak of color, CO_2, turbidity and iron which was reached during this period has lessened each succeeding year. However, weekly averages within the past year show the following variations: color 13 to 54 p.p.m., pH 6.0 to 6.9, CO_2 1.5 to 11.4 p.p.m., turbidity 0.4 to 6.3 p.p.m., iron 0.05 to 1.42 p.p.m., manganese 0.02 to 0.65 p.p.m. This disproves that this reservoir is stable or that we are treating a water with constant characteristics.

Yearly averages of characteristics of the raw water are shown in Table 1 for the fiscal years ending September 30. Interpretation of these should be made, however, only after reference to Figure 1 for information as to intake used, etc.

TABLE 1.— SUMMARY OF RAW WATER CHARACTERISTICS.
(Averages for Fiscal Years Ending September 30.)

	1927.	1928.	1929.	1930.	1931.*
Color — p.p.m.	32	36	32	19	17
pH	6.5	6.5	6.5	6.6	6.6
Alkalinity — p.p.m.	5.5	4.9	4.4	6.0	4.9
Carbon Dioxide — p.p.m.	5.5	4.4	3.9	3.0	2.8
Hardness — p.p.m.	8.8	7.4	5.7	7.2	8.3
Turbidity — p.p.m.	1.4	1.7	1.4	0.9	1.4
Iron (Fe) — p.p.m.	0.47†	0.65	0.64	0.27	0.25
Manganese (Mn) — p.p.m.	..	..	..	0.11‡	0.16
Dissolved Oxygen — Per cent. Saturation	..	46	58	72	73
Total Solids — p.p.m.	..	34	29	30	30
Fixed Solids — p.p.m.	..	..	15	14	17
B. Coli Index (Presumptive–per c.c.)	.005	.012	.004	.005	.013
Bacteria — 20° Count on Agar	91	72	60	44	60
Bacteria —37° Count on Agar	23	23	7	6	5

*Average Oct. 1930 to Jul. 1931. — 10 months.
†Average Jan. to Sep. 1927. — 9 months.
‡Average Mar. to Sep. 1930. — 7 months.

PURIFICATION.

Treatment of water has been in general as follows: aëration; alum dosing; mixing of approximately 20 minutes; coagulation and sedimentation of about two days; filtration; secondary aëration; hydrated-lime dosage. Chlorination of the aërated effluent and pre-chlorination have each been used at certain periods, as will be noted later. This method of treatment was employed up to August 9, 1931, when a change in treatment

was made. The new method consists of copperas (ferrous sulphate) dosing, aëration, lime treatment about to pH 10, mixing, coagulation and sedimentation, filtration and secondary aëration. The reason for this change will be stated later, but it is not intended to discuss the new treatment in this paper which will be restricted to facts and problems connected with the use of alum over a five-year period.

Influent Aëration. The influent aërator is equipped with New York type, rifled nozzles, with openings $1\frac{3}{8}$ in. in diameter, set in a perpendicular position. This aërator operates under a maximum gravity-head of 27 ft.

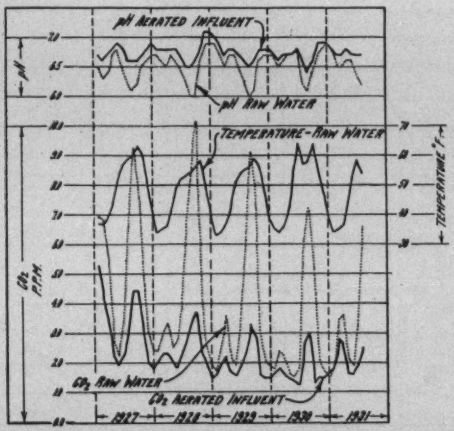

FIG. 2. — CHANGES IN CARBON DIOXIDE AND HYDROGEN-ION CONCENTRATION DURING INFLUENT AËRATION.

with a full reservoir. It is a beauty spot which attracts several thousand visitors annually. With the reservoir surface lowered 20 ft., as it was last winter, the aërator loses much of its beauty and efficiency. The esthetic appeal of aërators is such, however, that they may well be included in purification works, when it is possible to do so without extra cost for pumpage, even when they are not expected to be necessary to the purification process.

Aëration, however, is probably not valueless in treating any water. At Providence, one of its most valuable points is the destruction of microörganisms, which prevents the seeding of the coagulation basins. Because of the long retention period provided in these basins, dissolved gases in excess of their solution equilibrium would probably be given off in the basin if no influent aëration were provided. However, microorganisms would no doubt have seeded these basins at some time during

the past five years if they had not been broken up and destroyed by aëration and dragged down by the alum floc. Very seldom are micro-organisms found in the settled water entering the filters. During each of the first three fall seasons a certain amount of hydrogen sulphide was present in the raw water; this gas was entirely dissipated by influent aëration. A certain amount of vegetable odors has also been noticeable in late summer.

Carbon dioxide changes (as indicated by phenolphthalein titration) and pH changes due to aëration, together with the water temperature,

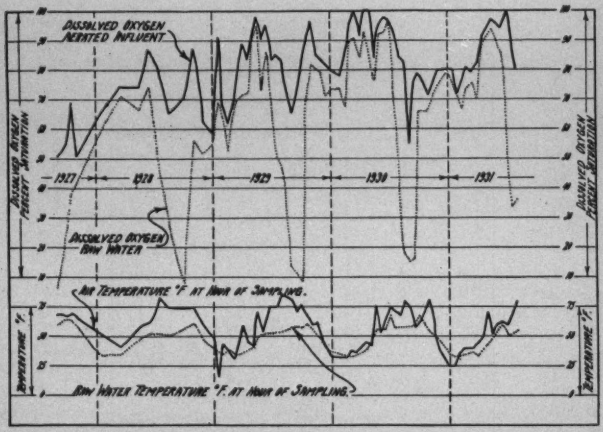

FIG. 3.— CHANGES IN DISSOLVED OXYGEN DURING INFLUENT AËRATION.

are shown on a monthly average basis in Figure 2. Increase in dissolved oxygen and temperature of air and water are shown on a semi-monthly test basis in Figure 3. A certain amount of the indicated CO_2 is not removable by any degree of aëration at the temperatures under which it takes place. The non-removable amount varies at different seasons and is greatest not in winter, as might be supposed because of the low temperature, but in late summer when humic and other organic acids increase. These are not removable by aëration alone, even at the higher air temperatures then prevailing.

There are shown in Table 2 average values for the fiscal years for pH, carbon dioxide, and dissolved oxygen in raw and aërated water, pH and dissolved-oxygen increase and carbon dioxide decrease, and approximate amount of indicated carbon dioxide which is non-removable by aëration. These averages indicate a probable average efficiency of about 70 per cent. The considerable drop in efficiency to 60 per cent. for 1931 is due to the decreased head caused by the drop in reservoir water level.

Precipitation of organic matter and iron in this aërator has required scrubbing it with brooms once or twice each year. Most of the precipitation takes place in the late summer and early fall. Microscopic growths have never bothered. Ice formation around the sides is sometimes marked. When operation is stopped the entire water surface is frozen, but no difficulty has been experienced, nor has any care been required in operation since small drain-pipes have been installed to draw the water out of the nozzles and drop the level in the large horizontal feed pipes below the constant water-level of the aërator.

Coagulation. Alum has been used as the coagulant, the amount required gradually having been reduced from an average of 0.66 grain

TABLE 2.— PERFORMANCE OF INFLUENT AËRATION.
(Averages for Fiscal Years Ending September 30.)

	1927*	1928.	1929.	1930.	1931.†
pH — Raw Water	6.4	6.5	6.5	6.6	6.6
pH — Aërated Water	6.7	6.7	6.8	6.7	6.8
pH — Increase	0.3	0.2	0.3	0.1	0.2
CO_2 — Raw Water (p.p.m.)	5.7	4.4	3.9	3.0	2.8
CO_2 — Aërated Water (p.p.m.)	3.5	2.5	2.1	1.8	1.9
CO_2 — Decrease (p.p.m.)	2.2	1.9	1.8	1.2	0.9
CO_2 — Non-Removable (p.p.m.)	2.6	1.7	1.5	1.2	1.3
Per cent. Efficiency of CO_2 removal	71	70	75	67	60
Dissolved Oxygen — Raw Water (Per cent. Saturation.)	..	46	58	72	73
Dissolved Oxygen — Aërated Water (Per cent. Saturation.)	..	68	79	87	84

*Average. — Jan. 1, 1927 to Sep. 30, 1927 — 9 months.
†Average. — Oct. 1, 1930 to Jul. 31, 1931 — 10 months.

per gal. during the first year, to what would appear to be practically the minimum possible dosage of 0.45 grain during the past year and a half. This means working in a zone where colloidal action is extremely slow and it would be impossible to obtain proper results with a coagulation period such as is nominally employed. The long sedimentation period provided, however, has made this operation possible; otherwise it would be necessary to add bicarbonates to the raw water in order to provide sufficient alkalinity to allow use of more alum to obtain a coarser and quicker settling floc. The monthly average alum dosage is shown in Figure 4 and the yearly average in Table 4.

The proper pH for best coagulation of this water is between 5.8 and 6.2. To obtain this pH in the treated water with the minimum of chemical

dosing, alum has been applied after influent aëration. If the alum was applied before aëration, the carbon dioxide released by the reaction of alum with bicarbonates would be given off and the pH raised. When alum is applied after aëration the carbon dioxide is given off very slowly; in fact, some of it is not given off until the water reaches the effluent aërator. The pH, therefore, is usually within the optimum range from the point of dosage through the coagulation basins and the filters, during an average period of approximately two days. The exact time of passage

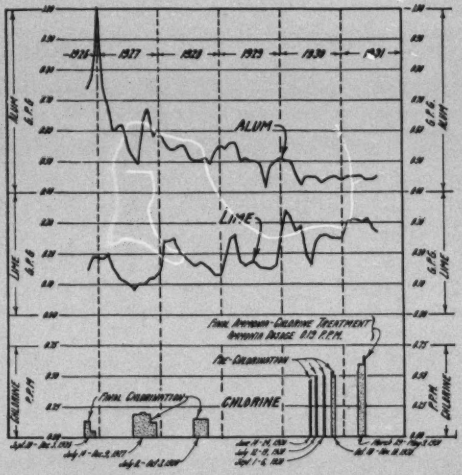

FIG. 4. — USE OF ALUM, LIME AND CHLORINE.

through the basins is not known. It is affected somewhat by the method of operation by which raw water is admitted to treatment during about 12 hours of the day, at double the filter rate, allowing the basin elevation to fluctuate about one foot. The total storage in the coagulation basins is equivalent to about five days' supply at the present average rate of use. That this long period of retention is essential to operation with such dilute solutions of coagulating chemicals, has been amply demonstrated by marked reductions in length of filter runs whenever this period has been shortened by cutting out the smaller basin and reducing the storage and retention to three-fourths its full value. The length of filter runs has always been cut proportionately to the retention and has increased again proportionately when operation on the longer period has been resumed.

The alum solution is mixed with the water in a rotary upward-flow gravity mixer. Mixing is thorough and it has been impossible to demonstrate that additional mixing would be advantageous.

Coagulation (floc formation) starts in the mixer within 20 minutes after the application of the alum solution, but the floc formed by the light dosage used is small in amount and light in character, and sedimentation is slow. Water entering the filters, however, has been carrying an average turbidity of only about 0.2 p.p.m. and a small amount of fine pinpoint floc. The most difficult period for coagulation has been the fall season before the turnover, the period when iron-organic compounds are increasing due to reservoir bottom stagnation. Pre-chlorination was used during certain periods in the summer and fall of 1930. Iron removal results were better during the periods of its use, as experiments had indicated would be the case, but no other evidence of benefit was seen.

No difficulty has ever been experienced with coagulation during colder weather, even though the temperature of the water is usually only 34 or 35°F during January and February. The coagulation basins are usually frozen over almost completely during these two months, but no difficulties have ever been experienced because of this. In fact, less alumina passed the filters in the winter of 1930–1931 than in the past summer. Run-off from an area of over one square mile drains into these coagulation basins and, of course, produces some dilution but this is not appreciable except at times of flood.

The larger coagulation basin, which also averages deeper and is the second in series as operated, has not been cleaned since it was put in operation in February, 1927. The smaller one was drained after one year's use, and some of the deepest sludge near the drain was flushed out. In the spring of 1930, after three years more of service, trouble was experienced when raw water from near the surface of the reservoir was being used. As soon as the temperature of water at the bottom of the coagulation basin was raised to about 70°F, biological action set in, and gases lifted the deposited sludge in masses. It was then necessary to drop the temperature, by using a lower reservoir-intake. This stopped the action and held the sludge down. The basin was cleaned completely in the fall by draining and flushing out with a hose stream under fire pressure. Sludge accumulation during the winter was not great, but the same floating action took place again in June 1931, making necessary the same change of intake as in 1930. This is the only difficulty which has ever been experienced in the operation of these basins.

A considerable saving in chemical costs has been effected by use of these large basins, not merely because of the reduced alum requirement, but also because coarser and quicker floc formation would have required the addition of alkalinity in bicarbonate form.

Filters and Filtration. Due to the long coagulation and sedimentation period which follows light chemical dosing, the floc entering the filters is extremely fine and small in quantity. Because of this fact, sand sizes and methods of operation for best results must be somewhat different than might be best in other plants. The sand, as it was originally placed,

had an effective size of 0.37 mm. and a uniformity coefficient of 1.46. Within a year the effective size increased to 0.40 mm., due to washing away a small amount of sand. Since that time the size has increased to 0.42 mm. without any appreciable variation from the original uniformity. This size of sand has given very satisfactory results with our water, whereas a sand of effective size 0.50 or 0.55 mm., as is often recommended today, would not give satisfactory results because of the high penetration of fine alum floc. Experimental results along this line have been quite conclusive. The 30-in. sand bed, which has been reduced to about 27 in., is supported on 12 in. of gravel and 6 in. of stone (1 to 2 in. in diameter) in which the underdrains of 3-in. cast-iron pipe (cement-lined) are laid with $\frac{1}{2}$-in. holes directly in the bottom of the pipes. This filter construction has thus far proved to be very satisfactory. Washing the filters has been accomplished without undue disturbance of the gravel and sand layers, and the grading of the sand in the filters is quite uniform. Two typical analyses of sand taken at different depths in the filters are recorded in Table 3 to show the actual grading of the sand.

TABLE 3.— ANALYSIS OF FILTER SAND.

	FILTER 2-A. October 15, 1927.		FILTER 8-B. February 27, 1930.	
Depth below Surface, inches.	Effective Size, mm.	Uniformity Coefficient.	Effective Size, mm.	Uniformity Coefficient.
0 to 1	0.38	1.31	0.36	1.36
1 to 2	0.41	1.32	0.40	1.30
6	0.44	1.32	0.43	1.26
12	0.45	1.33	0.46	1.50
18	0.45	1.33	0.52	1.50
24 to 27	0.46	1.35	0.50	1.56

Accumulation of foreign matter on the filter sand has proved to be very small. There has been little trouble with mudballs; whenever they have appeared, a change in the wash rate has always removed them. Filter cracks have never caused trouble; in fact, shrinkage cracks have never penetrated deeply into the filters. Only one filter has ever received any special treatment. On that one there had accumulated some hard cakes of muddy material, and some mixing of the gravel and sand had taken place. While maintaining about 12 in. per minute rise of wash water, men standing on the wash-water gutters raked through the sand into the gravel, breaking up lumps and levelling the gravel layers. This treatment was effective, and the filter has since operated perfectly for over a year.

The greatest tendency towards accumulation of foreign matter in the filters is manifest during the early spring and fall seasons. It is during

these seasons that floc formation seems to be poorest, also that the floc mat on the surface of filters is toughest and shows the most shrinkage. The nature of the flocs formed during the various seasons is entirely different, and different rates of wash are required to lift the mat, barring all question of the rates necessary to produce the proper amount of sand scouring. Rates of wash used vary between 14 and 27 in. rise of water per minute, varying with the temperature. The total time of flow is 4 minutes 15 seconds, but the maximum expansion is held for only about

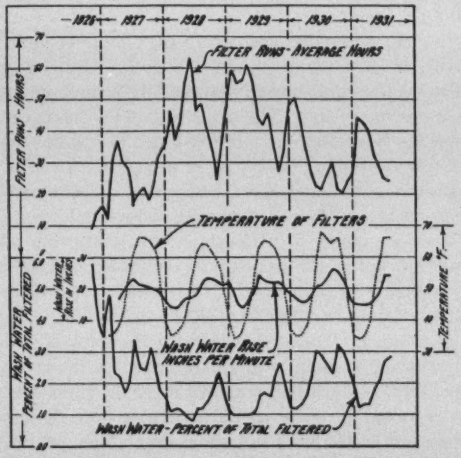

FIG. 5. — FILTER RUNS AND USE OF WASH WATER.

two minutes. This is caused by the fact that wash-water flow is controlled by hydraulically operated gates which open and close slowly, the wash water being drawn from an elevated storage tank. This method gives excellent control as it produces a gradual acceleration of flow and avoids "bumping" the filter and mixing the gravel with the sand. This probably accounts in large measure for the even grading noted in Table 3.

Filters are operated at a rate of only 110 m.g.d. per acre, to keep them in more constant operation, and all filters are washed at approximately 7-ft. loss of head. A higher loss of head could be used, as the total head available is 10 ft., but it has been found that for average practice it is not advisable to do so.

Washing filters is perhaps the most important point in plant control. Because of the very fine floc in our settled water, it has always been necessary to avoid over-washing the filters. It is not possible to wash until the water comes clear; a certain amount of the previously accumulated floc must be left at the end of the wash in water over the sand to settle

back onto the sand surface and form a gelatineous filter medium. If this is all washed away, the loss of head of the filter is less initially but increases much more rapidly, and the run is materially shortened; in some cases the run has been found to be only one-fourth as long as when the filter was properly washed. A tendency toward accumulation of foreign matter in the filters may nearly always be stopped by adjustment of the rate of wash (change of time of wash does not accomplish the same end), and the author believes that use of variable rates of wash is one of the chief reasons why it has not been necessary to remove or rehandle the sand in these filters.

Operating characteristics such as average hours of filter run per wash and per cent. wash-water used, are shown in Figure 5 on a monthly average basis. Filter runs during 1930 and 1931 have not compared well with those of previous years. The major reason for this is the fact that the upper intake has been used most of the time, as will be seen by referring to Figure 1. As stated previously, water from lower levels in the reservoir has always been coagulated more easily and satisfactorily. A second reason for shortened runs is that the smaller coagulating basin was out of service from September 5 to December 10, 1930, while the sludge was being cleaned out and the banks were being graded and rip-rapped.

Yearly averages of filter runs in hours and wash-water consumption in per cent. of total water filtered are shown in Table 4.

Effluent Aëration. The effluent aërator is equipped with West Palm Beach type whirling nozzles, with 1.2-in. openings, set to discharge at an angle of about 45°. The head available is 10 ft. minus the loss of head in the filter, leaving an operating head varying from 8½ down to 3 ft. or less. An even rate of filtration is maintained throughout the run by automatic operation of a by-pass mushroom controller; not all of the water, therefore, is discharged through the aërator nozzles. The average pH rise caused by aëration has been slightly over 0.2, and the average yearly carbon-dioxide removal has been from 5.8 to 4.2, 4.1 to 2.9, 3.5 to 2.5, 3.2 to 2.2, and 3.2 to 2.2 p.p.m. Neutralization of this carbon dioxide would have required a total of 186 tons of hydrated lime, in excess of that which was actually used. Dissolved oxygen changes have been as follows on a basis of yearly averages of per cent. of saturation for 1928, 1929, 1930 and 1931; filtered 75, 83, 87 and 84 per cent., aërated 84, 88, 89 and 83 per cent.

Odors have not been present in the filter effluents except during the overturn season. A vegetable odor may sometimes be detected at that season at this aërator, but only faintly.

Freezing has caused little trouble, and only a few times, early on cold mornings, has the aërator required any special attention to be kept in operation. Once "needle" ice from the coagulation basins was blown into the filter inlet wells and clogged them so that the head on the aërator was reduced and considerable freezing took place. At that time the aërator

was by-passed for a month (February, 1928), but this was done for the purpose of testing the by-pass butterfly control equipment. Operation of the aërator might have been resumed the same day if it had been desired.

TABLE 4.— SUMMARY OF OPERATION AND TREATMENT.
YEARLY AVERAGES, 1926–1931.
(Fiscal Years Ending September 30.)

	1927.	1928.	1929.	1930.	1931.*
Volume of Water Filtered — m.g.....	8 661.38	8 880.69	9 435.31	9 341.22	7 596.02
Volume of Water Filtered — m.g.d....	23.730	24.264	25.850	25.592	24.987
Alum — lb.	817 592	698 873	719 433	667 965	510 135
Alum — grains per gal.....	0.66	0.55	0.51	0.47	0.45
Hydrated Lime—lb.	170 342	224 055	288 650	312 300	300 650
Hydrated Lime — grains per gal. ...	0.14	0.18	0.17	0.24	0.28
Chlorine — lb.....	4 095	4 728	107	2 948	7 395
Chlorine — p.p.m...	0.18†	0.15†	..	0.50†	0.55†
Filters — Number of Washes.....	2 613	1 288	1 294	1 910	1 521
Filters — Average Hours Run.....	18.05	39.56	43.47	28.87	29.08
Wash Water — m.g..	276.83	121.10	137.42	205.47	156.92
Wash Water — per cent. of total filtered	3.20	1.37	1.45	2.20	2.66
Plant Effluent—m.g.	8 384.55	8 759.59	9 297.89	9 135.75	7 439.10
Plant Effluent — m.g.d.....	22.971	23.932	25.474	25.029	24.471

*Oct. 1, 1930 to Jul. 31, 1931. — 10 months.
†P.p.m. calculated on water actually treated; chlorine treatment of final effluent Sep. 30 to Dec. 5, 1926, Jul. 14 to Dec. 9, 1927, Jul. 8 to Oct. 3, 1928.
Raw water prechlorinated Jun. 14 to 24, Jul. 12 to 19, Sep. 1 to 6, Oct. 18 to Nov. 10, 1930.
Final Ammonia-Chlorine treatment Mar. 29 to May 9, 1931.—Ammonia dosage 0.19 p.p.m.

Lime Treatment. Lime treatment of the aërated effluent was provided for originally with the expectation of adding only enough lime to neutralize carbon dioxide to the point of reducing the corrosion of lead. The amount of dosage it was intended to use was so small that hydrated lime was chosen. After operating about a year at a final effluent pH of 7.4, it was decided that this was not entirely satisfactory, and the pH was increased to 7.7 to 7.9. Approximately this pH was carried until December 1929,

when it was again raised; the average pH since then has been about 9. This treatment was not sufficient to show marked immediate improvement, but the effect on red-water conditions in dead ends has since been quite striking. The amount of lime required for this treatment, running from 0.14 grain per gal. in 1927 to 0.28 in 1931, is shown in Table 4 and also in Figure 4. The pH changes produced, alkalinity increase, carbon dioxide neutralization and alkalinity to phenolpthalein, and lime dosage, are shown on a monthly average basis in Figure 6.

Bacteria and Algæ. Bacterial counts for the raw water have always been low, the numbers being such as to indicate drinking-water quality.

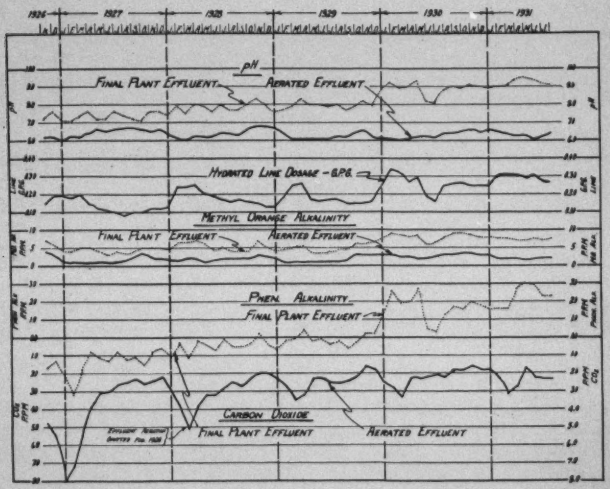

FIG. 6.— CORRECTION OF HYDROGEN-ION CONCENTRATION OF AËRATED FILTER EFFLUENT BY HYDRATED LIME.

Bacteria multiplied rapidly in the coagulation basins during the summer and fall of the first three years, and the aërated effluent was chlorinated. During the last two years, chlorination has been unnecessary at all seasons, as the bacterial quality has been excellent.

Ammonia-chlorine treatment of the final effluent was used from March 29 to May 9, 1931, not because of high bacterial content of the filter effluent, but to determine its effects on the distribution system.

Removal of bacteria in the filters has not been great. On the other hand, there has not been a time when there was not some reduction of bacteria. This is an indication of uniform performance. As will be noted in Table 5, *B. coli* pollution of the raw water as indicated by presumptive

tests is slight, and these organisms are all removed before filtration. An excellent bacterial quality of effluent has always been maintained, as will be seen by reference to Table 5, which shows the bacterial counts and *B. coli* indices for the raw water, settled water, filtered water, final effluent, and city tap-water on a basis of yearly averages.

Algæ have not caused troubles in operation since the first three weeks in 1926. A certain number are continually coming to the plant in the

TABLE 5.— SUMMARY OF BACTERIAL ANALYSES.
YEARLY AVERAGES, 1926–1931.
(Fiscal Years Ending September 30.)

	1927.	1928.	1929.	1930.	1931.*
B. Coli Index (Presumptive — per c.c.).					
Raw	.004	.012	.004	.005	.014
Settled	.008	.003	.002	.001	.001
Filtered	.004	.001	.001	.001	.000
Final Effluent†	.004	.001	.001	.001	.000
Tap (City)	.008	.001	.002	.000	.000
Bacterial Counts (20° C. Agar-Colonies per c.c.).					
Raw	91	72	60	44	66
Settled	1 213	467	231	472	467
Filtered	815	218	170	249	304
Final Effluent†	467	109	170	249	214
Tap (City)	105	27	35	27	94
Bacterial Counts (37° C. Agar-Colonies per c.c.).					
Raw	23	12	7	6	5
Settled	307	21	3	11	8
Filtered	318	7	2	4	4
Final Effluent†	162	4	2	4	4
Tap (City)	43	4	1	1	2

*Average Oct. 1931 to Jul. 1931. — 10 months.
†Final Effluent Average — filtered water chlorinated, Sep. 30 to Dec. 5, 1926; Jul. 14 to Dec. 9, 1927; Jul. 8 to Oct. 3, 1928; Mar. 29 to May 9, 1931.

raw water, though the count is usually less than 300 cubic standard units and often less than 100. These are broken up in the influent aërator, as mentioned before, and practically all organisms are dragged down in the coagulation basins. Practically never are organisms found in the plant effluent, and algæ have not affected the operation of the filters.

Plant Effluent Quality and Distribution System. The plant-effluent quality has been improved from year to year until it would be hard to find, or produce, a more satisfactory water than that delivered to Providence during the past year. The water has been soft and almost colorless. Tastes and odors have been absent except for two weeks during the over-

turn in 1930. The water has been low in total solids, being desirable for boiler purposes, and very low in iron and also in alumina. The bacterial quality of the plant effluent has been excellent. The bactericidal action of the lime treatment produced by raising the pH from about 6 to 9, as will be seen by reference to Table 5, has also decreased bacterial counts in the distribution system. Corrosiveness of the water has been well controlled during the past year by this pH correction. Complaints from deadend troubles have been nearly eliminated. Tests have indicated that a very satisfactory quality of water has been received in most of the dead ends. The taking into solution of iron between the plant and the city has been reduced to 0.05 p.p.m. Of 20 tests made between February and July 1931, not one showed the presence of lead when testing for 0.01 p.p.m. Precipitates in the system have shown very small percentages of alumina but increasingly large percentages of manganese.

The presence of manganese in the supply had not been ascertained until February 1930, when it was found to be present in the water in all parts of the system and in some precipitates in the conduits. There seems to be sufficient evidence that the amount of manganese present in the water previous to the beginning of 1930 had been small. Reference to Figure 1 will show that the amount increased rapidly during the summer and did not decrease during the winter even though surface water was drawn. An average of about 0.17 p.p.m. of manganese was present in the raw water during the past year. This was not removed by the purification process. After the final lime treatment, raising the pH, precipitation began immediately. Just how much of the manganese precipitated is not known, but there is evidence that a considerable percentage did. Ten tons of manganic oxide (which is the equivalent of the manganese in the plant effluent during the past year) is a considerable amount of black sediment. This sediment gave little trouble during the winter due to the low rates of draft, but with the increased drafts of spring, "dirty water" complaints became numerous and continued to come in on every day of high draft until the peak of consumption was reached.

The need for the removal of this manganese from the supply was the reason for the complete change of process on August 9, 1931. From all other standpoints the alum purification process produced an excellent quality of water. Some of the plant-effluent characteristics are shown on a monthly-average basis in Figure 6, and the yearly averages of these as well as additional characteristics are shown in Table 6.

Chemicals. The quantity of chemicals required each year is shown in Table 4. Alum has been bought under contract according to the following specification: "The sulphate of alumina furnished shall be basic, shall contain not less than seventeen per cent. of available water-soluble alumina (Al_2O_3), and shall not contain more than seventy-five one-hundredths of one per cent. of iron (Fe_2O_3). It shall contain not exceeding three per cent. of dust and fine particles passing a screen having twenty meshes per inch,

nor exceeding ten per cent. of particles passing screen having ten meshes per inch, nor any particles larger than will pass a three-quarter inch screen."

Hydrated lime has been bought under specification requiring at least 90 per cent. of water-soluble hydrate.

Chlorine is obtained from any of three local concerns under order, when required.

Miscellaneous. The population served by the system is now approximately 321 000, including all of the city of Providence and parts of Crans-

TABLE 6.— CHARACTERISTICS OF PLANT EFFLUENT.
YEARLY AVERAGES.
(Fiscal Years Ending September 30.)

	1927.	1928.	1929.	1930.	1931.*
Color — p.p.m.	7	7	6	3	3
pH	7.3	7.7	7.9	8.7	9.2
Alkalinity (Methyl-Orange) — p.p.m.	4.6	5.6	4.7	7.7	7.5
Carbon Dioxide — p.p.m.	1.4	0.6	0.3	0.0	0.0
Phenolphthalein Alkalinity — p.p.m.	0.0	0.0	0.0	1.3	2.2
Hardness — p.p.m.	15.1	14.9	11.2	14.3	17.4
Turbidity — p.p.m.	0.0	0.0	0.0	0.0	0.0
Iron (Fe) — p.p.m.	0.24†	0.32	0.23	0.08	0.04
Manganese (Mn) — p.p.m.	..	..	..	0.11‡	0.17
Silica§ (SiO_2) — p.p.m.	1.95	2.48	4.66	5.07	6.01
Alumina§ (Al_2O_3) — p.p.m.	.44	.53	.23	.21	.30
Calcium§ (Ca) — p.p.m.	5.70	4.08	4.28	6.10	6.41
Magnesium§ (Mg) — p.p.m.	1.10	.72	.52	.40	..
Sulphate§ (SO_4) — p.p.m.	14.00	8.52	7.66	7.71	..
Dissolved Oxygen — Per cent. saturation	..	84	88	89	83
B. Coli Index — Presumptive per c.c.	.004	.001	.001	.001	.000
Bacterial Count — 20° C, Agar	467	109	170	249	214
Bacterial Count — 37° C, Agar	162	4	2	4	4

*Average Oct. 1930 to Jul. 1931. — 10 months.
†Average Apr. to Sep. 1927. — 6 months.
‡Average Mar. to Sep. 1930. — 7 months.
§Average Analysis of city tap, not the plant effluent.

ton, Johnston, North Providence and Warwick. The average consumption is about 25 m.g.d., as shown in Table 4, with a maximum of about 32. Fluctuations in draft are carried to a considerable extent by Neutaconkanut Reservoir (38-m.g. capacity), to which the supply is fed by gravity from the plant. An electrically operated gage installed at the plant indicates the elevation of water in this reservoir which is seven miles distant.

Operation of the plant requires an average of less than 400 k.w.h. current per day, this is used for lighting, laboratory purposes, operation of the chemical-feed machines and pumping of water. From one to three per cent. of the total water filtered is pumped for washing the filters, also

a small amount for service water about the plant and at the five houses owned by the city and rented to employees.

Heating has required from 215 to 240 tons of bituminous coal each year. The design of the plant is such as to leave a minimum of cubical space to be heated, and this is reflected in the low consumption of coal.

The operating personnel of the purification plant proper consists of a master mechanic and eight "utility men" each working six eight-hour shifts per week.

There is a laboratory personnel of two, and routine tests of the water passing through the purification process are made; also tests of water, precipitates, etc., from the distribution system. Data as complete as possible are gathered on the condition of streams on the watershed and conditions and reactions in the impounding reservoirs. Investigations of reactions and results in the plant itself are necessary, and experimental work with various coagulants and methods of use make up a rather full year's schedule, in which nearly 30 000 tests are recorded. The value of such a mass of data will be questioned by some, but the author believes that the experiences at Providence during the past two years have amply demonstrated the value of complete data. Some of the points in which proper laboratory control produces results are: saving in chemicals; production of better effluent with less variation than would otherwise result; saving in power, labor, cost of materials and equipment for operation and also for sand handling and washing by avoiding the necessity for removing the sand; foretelling and forestalling troubles in the purification process itself or in the distribution system; testing out and developing new processes of treatment or otherwise refining the old processes.

OPERATION OF THE GREENWICH, CONN., FILTER PLANT.

BY HAROLD C. CHANDLER.*

[*Read October 1, 1931.*]

In 1928, papers describing the present and proposed developments of the Greenwich, Conn., Water Works were presented to this Association by Dana M. Wood† and E. Sherman Chase‡ of Stone & Webster and of Metcalf & Eddy, respectively, construction and designing engineers of the new Greenwich filter plant, which was placed in operation on April 26, 1928. These papers set forth the details of design and construction of the plant, together with the results of the first three months of operation.

The first part of the present paper, dealing with the sources of supply and the system of plant operation at Greenwich, gives largely the same data as presented by Messrs. Wood and Chase, a recapitulation of which may be of value, however, in connection with what is to follow.

Sources of Supply.

The two principal sources of water supply are Putnam Lake, on the southern shore of which the plant is situated, and Rockwood Lake. Putnam Lake is about four miles north of the center of Greenwich and has a watershed area of $1\frac{3}{4}$ sq. miles and a capacity of 750 m.g. In addition a six-foot tunnel, about a mile long, conveys water from the eastern branch of the Byram River to Putnam Lake, adding $4\frac{1}{2}$ sq. miles of watershed, which includes the catchment area of Converse Lake, privately owned.

Rockwood Lake lies northeast of Putnam Lake and supplies water to the latter by gravity through a 20-in. pipe whenever necessary, the usual practice being to maintain a reasonably high level in Putnam Lake in order to minimize the cost of pumping and purification at the filter plant. Rockwood Lake has a catchment area of one sq. mile and a capacity of 500 m.g. It is also supplied with additional water from a branch of the Mianus River,— called Pipen Brook,— by gravity and from the Mianus River itself by means of two 1-m.g.d. centrifugal pumps. This water is conveyed to Rockwood Lake through a 20-in. pipe. An agreement with the owners of property on the Mianus River below the pumping station provides for the use of this water by the Greenwich Water Company between October 1 and June 15. The pumping station is an asset to the company in that it affords a means of refilling Rockwood Lake during the winter and spring months following a dry season. This would not other-

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†Jour. N.E.W.W.A., Vol. 42, 1928, p. 378.

‡Jour. N.E.W.W.A., Vol. 42, 1928, p. 396.

wise be possible. The watershed area of the river above the pumping station is approximately 17 sq. miles, most of which lies in the state of New York.

The combined catchment area of all the sources of supply is 25 sq. miles.

Periodical inspections of the watershed are made, and all violations of the Connecticut State Sanitary Code and the Watershed Rules and Regulations of the state of New York are caused to be abated.

Population Served.

The Greenwich plant supplies Greenwich, Conn., and Port Chester and Rye, N. Y. The present estimated population of Greenwich is 34 000 and of Port Chester and Rye, 36 000.

System of Operation.

The normal capacity of the filter plant is 8 m.g.d. Raw water is pumped from Putnam Lake to the aërator, which is located on the roof of the coagulation basin, by means of two Warren centrifugal pumps, each having a rated capacity of 8 m.g.d. under a 55-ft. head. These pumps are driven by 100-h.p. General Electric, variable speed motors, operated by remote control from the operators' office, as well as from the pump house itself. The motors are equipped with temperature overload relays and devices for protection against single-phase operation.

Aëration is the first step in the purification process. The aërator consists of 48 Sacramento, two-pound-cone nozzles in six rows of seven nozzles each, the normal capacity of each nozzle being 100 g.p.m.

In order to clarify further explanation of the system of operation, it may be well to mention one particular feature of the design of the plant at this point. A system of four concrete flumes, one on top of the other, runs the full length of one side of the coagulation basin. The top flume, which is open at the top, collects the aërated water; the third flume conveys treated water to the coagulation basin itself; the second flume receives the coagulated and settled water for filtration, while the fourth, or bottom flume acts as a drain for the removal of sludge when the coagulation basin is cleaned.

The aërated water flows from the sloping roof of the coagulation basin into the top flume and then by pipe line to one of two 40 000-gal. square mixing tanks, where alum is applied. Each tank is equipped with inclined wooden paddles fastened to a vertical shaft rotating normally at a rate of 2 r.p.m., which speed can be varied, if desired, by means of interchangeable gears. The paddles are driven by 1-h.p. motors geared down in the ratio of 864 to 1. Aërated water enters at the top of the tanks and discharges at the bottom. It is afforded a retention period in each tank

of seven minutes at an 8-m.g.d. rate. Alum is applied by means of two Gauntt, dry-feed machines located in the mixing room close to the mixing tanks.

As previously stated, the treated water flows to the coagulation basin by way of the third flume. This basin has a capacity of 1 m.g.d. and is divided into three compartments which operate in parallel, each compartment being equipped with a central, longitudinal, vertical, wooden, around-the-end baffle. The retention period is three hours at the normal rate of operation. Each compartment is emptied separately, by gravity, for cleaning.

Settled water flows from each compartment of the coagulation basin over a skimming weir into the second flume, which supplies two pipe lines leading to eight open, ½-m.g.d. rapid sand-filters at the new plant and twelve ¼-m.g.d. and two ½-m.g.d. pressure filters at the old plant some 1 500 ft. distant. The gravity filters are operated continuously, while the pressure filters take care of the fluctuations in the demand and are put out of service at night when the rate of consumption is less than 4 m.g.d. The amount of water supplying the old plant is regulated by means of an adjustable orifice adjacent to the settled-water flume, the water entering a 16-in. pipe, after passing through the orifice, which leads to this plant.

Each of the gravity filters consists of 30 in. of sand, 18 in. of gravel in five layers varying in size from 1 to ⅛ in. The filters are underdrained by cast-iron laterals with ¼-in. openings spaced 3 in. apart on the two lower quadrants. All valves are hydraulically operated from operating tables equipped with indicating loss-of-head gages and recording rate-of-flow gages. The rate of flow is controlled by means of Builders' Iron Foundry direct-acting rate controllers.

The pressure filters contain approximately three feet of sand and two feet of gravel.

The gravity filters discharge into a 24-in. pipe which leads to the 1-m.g. concrete, covered clear well. Chlorine is applied just ahead of the clear well, two Wallace & Tiernan MSVM chlorinators being used for this purpose, one serving as a spare unit for chlorinating the treated or settled water, if necessary. The clear well is 12½ ft. deep and is so constructed as to allow for the installation of an aërator on its roof for post-aëration, if desired. The difference in elevation between the water level in the filters and the high level in the clear well is ten feet, which means that, in the event post-aëration is adopted, the filtered water will have to be pumped to the aërator. A recording clear-well depth gage is provided in the operators' office.

The effluent of the clear well flows by gravity through a 24-in. pipe, followed by a 30-in. pipe, to the old plant, where it mixes with the effluent of the pressure filters, these units discharging into this pipe line at three points after it is again reduced to 24 in. An overdose of lime, sufficient to treat the effluents of both plants, and a second dose of chlorine are

applied to the clear-well effluent. Lime is applied as the water leaves the clear well; chlorine, just ahead of the old plant. This second dose of chlorine is just sufficient to treat the old plant effluent and maintain a residual of 0.10 p.p.m. in the mixed effluent. A Savage, Gauntt-type, dry-feed machine, located in the mixing room at the new plant, is used for the application of lime, while the second dose of chlorine is applied by means of two Wallace & Tiernan direct-feed chlorinators at the old plant.

It has been possible to maintain proper residuals, during the colder months of the year, in the mixed effluent by applying chlorine to the settled water fed to the old plant, using the spare chlorinator at the new plant for this purpose and discontinuing the use of the chlorinators at the old plant.

Distribution of the plant effluent is by gravity, the elevation of the clear well being 316 ft. above sea level.

Builders' Iron Foundry indicating and recording Venturi meters, for measuring the total amount of raw water pumped from Putnam Lake and the wash water used at the new plant, are conveniently located in the operators' office. A similar meter at the old plant measures the flow from the clear well and affords a means of determining, by difference, the amount of water filtered at the old plant, allowance being made for the wash water used at the new plant and for clear-well fluctuations.

Two Warren, centrifugal pumps, operated by 50-h.p. General Electric motors, are used for washing the gravity filters. These are located in the basement of the filter and chemical house, and filtered water is pumped directly from the clear well to the filters. Each pump is of sufficient capacity to produce a vertical rise of 29 in. per minute above the sand in the filters. For higher velocities, both pumps are used simultaneously with the discharge valves throttled. The main discharge line of these pumps is equipped with a Builders' Iron Foundry, pilot-valve-operated, rate controller with an auxiliary hydraulic device for throwing the pilot valve into the closing position or releasing it. The pilot valve and auxiliary device are housed in the wash-water Venturi-meter casing, and a lever for operating the auxiliary device is provided on the operating floor of the filter gallery. Operation of the wash-water pumps is by remote control from the operating floor.

Washing at the old plant is accomplished by gravity, the difference in elevation between the clear well and the pressure filters being 60 ft. Valves at the old plant are manually controlled.

The second floor of the filter and chemical house affords storage space for a twenty-ton carload of lime and fifteen to twenty tons of alum. Alum is delivered at the plant in six-ton loads. A hydraulic elevator is provided for moving all heavy chemicals from a loading platform to the chemical-storage room, in one corner of which the chlorine room is located.

A Wallace & Tiernan vacuum feed chlorinator located in the low-lift pump house, is available for pre-chlorination.

One of the features of the plant is the laboratory, located on the first floor of the filter building, completely equipped for all phases of water examination.

Plant Performance.

Aëration. Aëration has been quite effective in the removal of gases causing taste and odor. Following dry periods, the raw water has acquired musty and disagreeable odors which have been almost completely removed by aëration. Algæ odors present just before and after treatment of the lakes with copper sulphate have also been considerably reduced.

During the winter months, when aëration is not required, the aërator is put out of service, thereby avoiding freezing difficulties and reducing the head on the low-lift pumps ten to fifteen feet. A by-passing arrangement of piping, whereby raw water is pumped directly to the mixing tanks, is provided.

The carbon-dioxide content of the raw water is rarely higher than 3 p.p.m. It may be said, therefore, that CO_2 removal is not an important problem at this stage of the purification process, although high efficiency is indicated in this respect.

Mixing and Coagulation. The mixing tanks are a decided asset to the coagulation process. This is excellently illustrated by laboratory experiments with a motor-driven mixing machine which is used regularly for determining the optimum alum dose. No attempt has been made to vary the speed of the mixing paddles, as it has been found that a speed of 2 r.p.m. results in the formation of an excellent floc immediately after the water enters the coagulation basin.

As the treated water flows through the coagulation basin, the bulk of the coagulated material is deposited at or near the open end of the wooden baffles. Practically no sludge is to be found near the outlets.

The coagulation basin is cleaned periodically, the depth of accumulated sludge and character of the settled water serving as an indication of the proper time to do so. The period between cleanings averages about four weeks, varying from three weeks in warm weather to six or seven weeks in winter. The cleaning process requires the services of two men for operating sluice gates and hosing down the walls and sloping floor. The sludge is removed by gravity. There are two sluice gates in each compartment opening into the bottom flume, from which the sludge flows into a 24-in. tile pipe-line to the brook below Putnam Lake spillway. A two-stage, centrifugal pump supplies raw water for flushing to hydrants, located on either side of the basin.

Filtration. Two entirely different types of sand have been used in the filters. Six of the gravity filters contain Cape May sand having an original effective size of 0.36 mm. and a uniformity coefficient of 1.45. The remaining two gravity filters and all of the pressure filters contain

Cow Bay, Long Island, sand with an effective size of 0.36 mm. and a uniformity coefficient of 4.2. The quality of the filtered water has been the same with either type of sand, the only difference in operation being in the length of runs. After the filters containing Cow Bay sand had been backwashed and a few inches of sand had been scraped off the top, a run of twelve hours resulted, whereas, for the filters containing Cape May sand, the lengths of run were much shorter, beginning with four hours and gradually increasing during the first few months of operation. The difference in the performance of these sands may be accounted for by the fact that the Cow Bay sand contains a large amount of very fine material which is rapidly removed when washed, resulting in an effective size larger than that of the Cape May sand. Another advantage in the use of Cow Bay sand is that it can be obtained at a low cost from a local dealer. Mechanical analysis of samples collected from the gravity filters in September, 1931, are given in the following table:

	Effective Size (mm.).		Uniformity Coefficient.	
Filter No.	Top 1-in.	Composite.	Top 1-in.	Composite.
1	0.315	0.412	1.32	2.72
2	0.315	0.395	1.30	2.39
3	0.315	0.410	1.41	1.32
4	0.325	0.430	1.47	1.29
5	0.312	0.365	1.39	1.49
6	0.320	0.420	1.47	1.33
7	0.315	0.368	1.43	1.48
8	0.332	0.428	1.47	1.31

Filters 1 and 2 contain Cow Bay sand.
Filters 3 to 8 contain Cape May sand.

No filter troubles have been experienced at the new plant. After three years of operation, the filters are in excellent condition, due to the fact that a system of washing has been adopted which makes use of a wash-water velocity sufficient to produce a 50 per cent. expansion of the sand at all times. This is accomplished by varying the vertical rise of wash water above the sand from 29 in. per minute in winter to 42 in. per minute in the summer, as the temperature of the water varies. It may be said at this point that the surest way to avoid filter troubles is to insure proper washing by the use of a sufficient wash-water velocity to produce a 50 per cent. expansion of the sand, particularly when the raw water is colored, low in turbidity and subject to algæ growths, as is the case with most impounded surface waters common to New England.

Raking of the gravity filters, while washing, to break up mud formations, has been a routine practice.

The process of "cracking" the filters between washes has often been used with a great deal of success as a means of saving wash-water and lengthening the runs.

Due to the fact that the head available for washing the pressure filters at the old plant is not sufficient to produce the desired expansion

of the sand in these beds, it has been necessary to replace some of the sand each year.

Lime Treatment. During the first year of operation of the plant, soda ash was used for correcting the corrosive properties of the filtered water. Lime was then substituted for soda ash at a considerable saving, the only effect upon the quality of the filtered water being an increase in the hardness of 10 p.p.m., which is hardly noticeable to the consumer.

Following the fall overturns of the past two dry seasons, when the lakes were very low, the raw water contained 0.3 to 0.5 p.p.m. of manganese, none of which could be removed by the regular purification process. The point of application of lime was changed from the filtered water to the settled water with the idea of removing the manganese before filtration. This method of operation was very effective. It was found that at least two-thirds of the manganese present was removed without increasing the alum and lime dose which would ordinarily be required. However, the color of the filtered water was increased from 2 to 7 p.p.m; this increase was barely noticeable to the ordinary consumer.

Control of Algæ. Rockwood and Putnam Lakes are subject to objectionable algæ growths during the warmer months, the blue-green algæ, particularly *Anabæna*, being the most troublesome from the standpoint of odor and taste. As was the custom before the new filter plant was constructed, copper-sulphate treatment of the lakes is employed three or four times a year, or as often as necessary, to destroy these organisms, thereby insuring complete elimination of taste and odor, as well as improving the operating condition of the filters. It has been found that the blue-green algæ, as well as certain *diatoms*, decidedly effect the length of runs of the filters by forming a dense resistant mat on the surface of the sand. Immediately after treating Putnam Lake with copper sulphate, the length of the filter runs has been considerably increased.

Miscellaneous Experiences. Sodium aluminate and chlorinated copperas have both been tried in the laboratory, and the former, in actual operation. Fair results were obtained with each, but practically no saving was indicated by either method in the cost of treatment.

Warm-weather consumption during the past two years has been so great as to cause the plant to be taxed to its utmost capacity, peak loads of 12 to 15 m.g.d. from 8.00 A.M. to 9.00 P.M. often being experienced. Aërator, filters and basins were overloaded from 25 to 50 per cent. without materially affecting the quality of the plant effluent, although it was necessary to operate both of the low-lift pumps and both alum machines simultaneously and wash all of the gravity filters at night in order to meet the excessive demand during the day and fill the clear well at night. Greater storage capacity for filtered water would temporarily relieve the plant of this excessive burden, and the addition of a 2-m.g. clear well to the present 1-m.g. basin has been proposed and is now being planned. The filter and chemical building is so constructed as to allow for the addition of eight

more ½-m.g.d. gravity filters on the end of the building opposite the present filter wing, and provision has also been made for increasing the size of the coagulation basin, as it was foreseen at the time of building the plant that the growth of the communities served would be rapid and that it would eventually be necessary to increase the size of the plant.

The drought of the past two years has developed the need for additional sources of supply in the not far distant future. Low-water conditions in Putnam Lake during this extended dry period have resulted in greatly increasing the cost of low-lift pumping as well as that of chemical treatment. At one time last year, furthermore, only a few weeks' supply of water remained in storage, excluding Converse Lake, which had not been tapped.

Some trouble has been experienced with the operation of the 16-in. check valves in the discharge lines of the two low-lift pumps. On two or three occasions, these valves have stuck in the open position when the pumps were shut down, causing the pumps to rotate in the wrong direction at great speed, following which, the valves closed suddenly, resulting in a terrific jolt on the entire pumping system and all but rooting the pumps from their foundations. The greater part of the strain was borne by lead joints in the discharge lines, which accounts for the fact that there were no serious consequences. The installation of rubber bumpers on the center bolts of the valve disks, preventing the disks from rising high enough to come in contact with the upper part of the valve housing, has apparently overcome this difficulty.

The gravity and pressure filters were treated with a 1-per cent. solution of caustic soda after the first and third year of operation as a means of cleaning the sand, the greater part of the accumulated alum and organic impurities being removed by the process. The quality of the raw water has been fairly uniform, and no great extremes in the chemical dose have been required.

Four operators are required to run the plant, the arrangement being such that two men are always on duty at night.

General operation of the plant has been consistently good, and the quality of the plant effluent has been excellent at all times.

Cost of Operation. The average cost of operation per million gallons,— not including any fixed charges,— during the first three years was as follows:

Year.	Chemicals.	Labor.	Heat.	Power.	Total.
1	4.41	5.80	0.75	5.80	$16.76
2	2.73	7.10	0.47	6.30	16.60
3	3.17	6.85	0.46	6.50	16.98

SUMMARY OF PHYSICAL, CHEMICAL AND BACTERIOLOGICAL ANALYSIS.

	Turbidity. p.p.m.		Color. p.p.m.		Alkalinity. p.p.m.		CO_2. p.p.m.		pH.		Bacteria per c.c., Agar, 37° C.		*Bact. Coli.* per 100 c.c.	
	R.	E.	R.	E.	R.	E.	R.	E.	R.	E.	R.	E.	R.	E.
Average....	4	1–	24	2	12.0	14.5	2.0	1.0	7.1	7.5	150	1	11.4	0
Minimum...	1	0	10	0	7.0	3.0	0	0	6.4	6.0	3	0	0	0
Maximum..	20	1	55	12	18.0	32.0	7.0	7.0	8.1	8.7	5 000	500	1 000	4

R. — Raw Water. E. — Plant Effluent.

SUMMARY OF OPERATION AND CHEMICAL TREATMENT.

	Water Delivered. m.g.	Wash Water, m.g.		Gravity Filters.				
				M.g.d. per acre.		No. of Washes.	Per cent. Wash Water.	Length of Runs. Hours.
		Gravity Filters.	Pressure Filters.	Yield.	Rate.			
Daily Average....	5.24	0.15	0.07	118	131	7	4.2	23.0
Daily Minimum...	3.77	0	0.03	86	117	0	0	3.7
Daily Maximum ..	9.32	0.25	0.10	149	156	27	14.0	51.0

	Pressure Filters.*		Rate of Chemical Application.				Power and Lights. k.w.h.
	No. of Washes.	Per cent. of Wash Water.	Alum. grains per gal.	Soda Ash. p.p.m.	Lime. p.p.m.	Colorine. p.p.m.	
Daily Average.....	10	4.2	1.0	13.0	8.0	0.50	1 644
Daily Minimum...	4	1.0	0.6	7.0	3.5	0.25	1 120
Daily Maximum...	14	14.0	1.4	23.5	13.0	1.15	3 040

*Pressure filters in use washed once daily.

WATER FILTRATION AT HARTFORD.

BY W. A. GENTNER.*

[*Read October 1, 1931.*]

The water-supply system of the city of Hartford, Conn., has been municipally owned and operated since the date of its inception in 1854. On July 1, 1930, ownership and operation were transferred from the city of Hartford to the Metropolitan District of Hartford County.

The system at present supplies water to the city of Hartford and five surrounding towns. Its distribution system covers an area of approximately 56 sq. miles and in 1930 served an estimated population of 212 000 with an average volume of 18.63 m.g.d. of water.

The decade from 1912 to 1922 is notable in the history of this system in that it marked an era of unprecedented betterments and extensions to the system, resulting in the development of an entirely new source of supply and the introduction of the slow sand method of water filtration.

Source of Supply.

The old source of supply consisting of six small reservoirs, located some six miles west of Hartford, had a total storage capacity of 2 036 m.g. and an estimated safe yield of about 7.5 m.g.d. Of these six West Hartford reservoirs, two are no longer used for water-supply purposes and the remaining four with a combined available capacity of 1 272 m.g. are held as reserve and emergency supplies.

The Nepaug Reservoir, the new source of supply, is eight miles west of the West Hartford reservoir-system to which it is connected by a 42-in. cast-iron pipe line. This reservoir, with a watershed area of 32 sq. miles, has a total capacity of 9½ billion gal. and a safe estimated yield of 25 m.g.d.

Filters.

The decision to adopt slow sand-filtration resulted from long and exhaustive studies and experiments and careful consideration of local conditions. Water from either Nepaug or West Hartford is particularly well adapted to this method of treatment on account of its low color and turbidity. In addition to these two factors, strong local opposition to the use of chemicals in water treatment combined with lower operating cost of slow sand plants and an abundance of unused land in the West Hartford reservation, conveniently situated for purification-plant purposes, ultimately led to the selection of this type of filters.

*Office Engineer, Water Bureau, Hartford, Conn.

Work on the filter plant was begun in April 1919, and the filtration of water was inaugurated on February 6, 1922 and has since continued without interruption.

The principal features of the original plant were:

1. Mixing chamber.
2. Fountain aërator.
3. Filter plant of 8 one-half acre beds, with two regulator houses and an office building.
4. Filtered-water basin of 6 m.g. capacity.

The mixing chamber is a one-story circular rubble-masonry building, 25 ft. in diameter. It houses an arrangement of piping and gates which permits the use of raw water from either the Nepaug or West Hartford sources or a mixture of both in any desired ratio.

The aërator is a circular reinforced concrete basin, 40 ft. in diameter, into which water falls, after having first passed through a series of center jets or slotted orifices spaced around the rim of the pool.

The filter plant proper consists of eight covered masonry beds, an office building and two regulator houses. Beds are laid out in 13-ft. bays, each bed being approximately 169 ft. long and 143 ft. wide with a filtering area of about .53 acres. Walls are concrete; the roof and floors are of reinforced-concrete groined-arch construction with arches supported on concrete piers 20 in. square and 13 ft. on centers.

The underdrainage consists of half-round tile laterals in each bay, connected to a central main drain extending the length of the bed. The tile laterals range in size from 12 in. at the main drain to 6 in. at the far side of the bed. The main drain is rectangular in section, 24 in. wide and varies in depth from 9 to 24 in. for one-half its length, with a uniform depth of 24 in. for the half nearest the outlet.

The filtering material consists of 12 in. of gravel overlying the underdrainage system and 3 ft. of sand on top of the gravel. The sand has an effective size of 0.29 mm. and a uniformity coefficient of 2.0.

The filter beds are centered in groups of four about the two regulator houses which contain the necessary piping and control equipment for properly regulating flow through the four beds. A tunnel, containing wash-water pipes, heat conduits and a sanitary sewer, connects the two regulator houses and extends to the office building at the extreme north end of the plant, making it possible to reach all parts of the plant without going out of doors. The piping housed in the tunnel is always accessible for inspection and can easily be replaced when necessary.

This grouping of beds about a central regulating house, the arrangement of piping in the regulator houses and the centrally located tunnel connecting the regulator houses are adaptions from rapid sand plants and are the first installations of their kind in a slow sand plant. A similar

arrangement was later incorporated in the design and construction of the Springfield, Massachusetts plant by the late Allen Hazen.

The office building houses the superintendent's office, water analysis laboratory, heating plant, wash water pump, and gates on raw- and filtered-water mains. The superstructures of all filter buildings are of native trap rubble masonry with artificial stone trim.

The filtered-water reservoir is a covered masonry chamber 245 ft. square and 15 ft. deep with a capacity of approximately 6 m.g. It is similar in design and construction to the filter beds.

Incidental to the construction of the filter plant, a hydro-electric plant was built to furnish the power necessary to operate the filters and for general use throughout the reservation. The plant operates under a 45-ft. head taking water from one of the two reservoirs no longer used for water-supply purposes. It is equipped with the following two units:

1. S. Morgan Smith Company, 15-in. Type "O" turbine, direct connected to Western Electric 150-k.v.a., 600-volt, 3-phase alternator.
2. Holyoke Machine Company, 9-in. turbine, belt connected to Western Electric 25-k.v.a., 600-volt, 3-phase alternator.

The small wheel, equipped with proper safety devices, runs without attendance and is used continuously, except during sand-washing operations when it is replaced in service by the larger unit. The power plant is operated by the regular filter-operating force, and the entire cost of its operation and maintenance is charged against filter-plant operations and maintenance.

Two major additions have been made to the original plant described. In 1925 a 9-m.g. filtered-water basin was built. This basin is about 297 ft. square and 15 ft. deep.

In 1927–1928 two $\frac{3}{4}$-acre filter beds with a regulator house were added. These beds are 195 ft. long, 169 ft. wide and have a filtering area of .73 acre each. The design and construction used in each of these additions follows very closely that used in similar structures of the original plant.

A sand-storage bin with a capacity of 1 500 cu. yd. of sand was included in the addition to the filters. The bin has a base 25 x 30 ft., a depth of $15\frac{1}{2}$ ft. and sides with 1 on $1\frac{1}{2}$ slopes. It is without cover, has a 6-in. concrete floor, and its sides are paved with precast reinforced concrete slabs 3 in. thick, 2 ft. square with mortar joints between slabs. The top of the bin is practically level with the tops of the filters. It drains into a gravel-filled channel, which in turn drains to a concrete catch basin with an 8-in. tile outlet.

The present plant, therefore, consists of a mixing chamber, fountain aërator, 8 one-half acre beds with two regulator houses and office building, 2 three-quarter acre beds with a regulator house, one 6- and one 9-m.g. filtered-water reservoir. There are approximately 5.7 acres of filtering surface; the plant has an estimated filtering capacity of 27.5 m.g.d., and represents a capital outlay of close to $1 850 000, not including the cost of land.

Special efforts are made to keep the filter-plant grounds attractive. The lawns and grounds are simply but effectively landscaped with shrubs and evergreens, and the top of the filters adjacent to the office building has been developed with attractive flower gardens. Favorable comments from hundreds of visitors indicate that efforts along these lines are appreciated and that their continuance is well worth while.

Operating Force.

The operating force, consisting of eight men, is as follows: a superintendent, a chemist, four laborer operators and two watchmen. During sand-washing operations or resanding of beds, this force is temporarily increased by eleven others transferred from distribution labor gangs. The superintendent has direct charge of all work at the plant and is responsible for its satisfactory performance.

The chemist devotes his entire time to routine tests, by which a constant check is kept on the quality of water in storage and that being delivered into the distribution system. These tests include the following:

1. Daily bacteriological and color examinations of raw water to the filters, aërated water, filtered water from a city tap and from each filter bed in operation.
2. Weekly alkalinity and hardness determinations of water delivered to the city and daily determinations of turbidity of raw water to the filters.
3. Determination of dissolved-oxygen content of aërated water, and influent and effluent of filter beds.
4. Weekly hydrogen-ion concentration (pH) of raw water to filters, aërated water and filtered water.

The four laborer operators do all ordinary operating work such as raking filter beds, taking care of gardens, lawns and grounds, operating power plant and making ordinary repairs to buildings and equipment.

The two watchmen are on duty at night. Special precautions are taken to insure proper plant operation and attendance at night. For this purpose the night watch is divided into two shifts with a watchman for each shift. In addition to making regular hourly rounds of the plant, the watchman is required to telephone the emergency crew on duty at the city supply yard each hour of the night. If this call is not received, the yard man calls the filters, and if he fails to get an answer, he calls the foreman's house at the West Hartford Reservoir. It is then the foreman's duty to make a personal trip to the filters to find out why the scheduled telephone call was not made. Under this plan it is impossible for the plant to be without proper attendance for a period longer than one hour. In the event of the telephone being out of order, both watchmen remain on duty during the night.

Method of Operation.

Water from either or both sources of supply first passes through the mixing chamber and then through the aërator where a thorough mixing with air takes place. From the aërator it passes through a 36-in. cast-iron pipe line to the filters. After filtration the water is carried through another 36-in. cast-iron pipe line to one or the other of the filtered-water reservoirs from which it is delivered directly to the 42-in. supply mains leading into the distribution system.

Rate of Filtration. The rate of filtration has a most important bearing on the operation of a slow sand-filtration plant. Overloading of beds results at once in abnormal losses of head, shorter filter runs, increased rakings and washings with a resulting increase in operating costs.

The operating scheme at the Hartford plant calls for two full filtered-water reservoirs (15 m.g. of water) each Monday morning, when rates for the following week are set. Familiarity with normal demands of the system, combined with proper consideration of plant conditions, enables the operator to set rates which frequently hold throughout the week. If necessary, week-end rates are adjusted to meet the Monday full-reservoir requirements. Abnormal conditions, such as fires, main-pipe breaks or extreme weather conditions, may and often do upset this uniform rate schedule.

Although the filtered-water reservoirs have a combined capacity of 15 m.g., only 6½ m.g. are available for ordinary use, the remaining 8½ m.g. being held in reserve for fire or emergency use. This restriction results in an allowable drawdown of 6½ ft. in the reservoirs, and a close check is maintained to prevent the water level from falling below this limit.

The Hartford plant has happily been free from major operating difficulties during its nearly ten years of service. Shortened filter runs are always a matter of concern, resulting as they do in loss of filter beds from service while raking or washing. Spring and fall over-turn periods in the reservoirs are more than likely to bring about this undesirable condition. This is sometimes avoided at the Hartford plant by switching from one source of supply to the other. In any event, every precaution is taken to have the beds in good condition as the over-turn time approaches.

Winter runs have been quite appreciably lengthened and operating conditions generally improved by shutting off the aërator during cold weather. With the aërator in operation, sprays of cold water coming into contact with the air permit an appreciable absorption of air by the water. This air is later released as the temperature of the water rises during its retention period in the filter beds resulting in the formation of air pockets or sub-surface clogging by air.

Last year, one bed in particular gave considerable trouble, because of short filter runs. Investigation disclosed a seam of dirty sand underlying a considerable portion of the bed, at a depth of about 14 in. below the sand surface. Various methods of washing it out were tried. Finally it was

successfully broken up and removed by jets of water from well points inserted into the sand at short distances throughout the bed. Following this treatment, no further trouble has been experienced, and the bed has operated normally. Apparently the streak formed during the resanding of the bed.

Another unusual operating experience of the past year which resulted in short filter runs was the formation on the sand surface of a pink jelly-like amorphous substance with an exceedingly offensive odor. Mr. H. W. Clark, Director and Chief Chemist of the Massachusetts State Department of Public Health, was consulted as to the cause and a possible remedy for this condition. He reported that the jelly-like growth was caused by organisms present in the raw water which very materially increased on the surface of the sand. He suggested drawing the filter down and dosing liberally with copper sulphate to destroy the organisms.

In 1930, 6.8 billion gal. of water were filtered at an average rate of filtration of 3.49 m.g.d. per acre. The maximum amount of water ever filtered in one day is 28 m.g. This output was registered with seven one-half acre and two three-quarter acre beds in commission and resulted in a rate of filtration of 5.41 m.g.d. per acre. The maximum rate for a period of one week is 5.31 m.g.d. per acre in the original plant with six one-half acre beds operating.

SUMMARY OF FILTER RUNS, 1930.

MILLION GALLONS OF WATER FILTERED.

	ONE-HALF ACRE BEDS.			THREE-QUARTER ACRE BEDS.		
	Max.	Min.	Avg.	Max.	Min.	Avg.
Washing.....	149.5	24.0	65.9	189.5	59.5	140.4
1st Raking....	112.5	30.	61.3	187.0	107.	146.8
2nd Raking....	121.5	12.	58.5	51.0	33.5	42.3
3rd Raking....	79.5	6.	47.8	88.5	83.	85.8
4th Raking....	87.	4.	49.8	102.5	77.	87.5
5th Raking....	70.	6.	29.2	74.5	74.5	74.5

Last year the plant was operated for a total of 3 407 bed-days out of a possible 3 650, leaving each bed an average out-of-service period of 24.3 days during the year.

Raking. There are normally between 5 and 6 ft. of water over the sand in each bed. When the lost head approaches 5 ft., preparations are made to rake the bed. Beds are raked five times between washings. Ordinary garden rakes are used for the first three rakings, but for the fourth and fifth, a heavier rake is employed with longer and wider-spaced teeth.

A half-acre bed can be raked by two men in two hours' time, a three-quarter acre bed requires three hours and three men.

Each raking a bed receives results in a 24-hour loss of its services as a filter unit. Inflow into a bed to be raked is stopped at six o'clock in the morning of the day preceding the raking. Twelve hours are allowed for filtering the water remaining in the bed at the time of the shut off. The small amount left on the sand at the end of this 12-hour period is wasted through the sump-well drain, and the bed is allowed to dry out until the next morning when the actual raking is made. Refilling is started immediately after raking has been completed. A very slow reverse flow is started upward through the sand, using water from an adjacent filter bed. This reverse flow is continued until water reaches a depth of 10 in. over the sand. With this protective cushion established, inflow valves are opened, and the bed fills and is ready for filtering service again at six o'clock that night.

Experiments have been attempted to substitute reverse flows for raking. The plant, however, was not designed for such procedure, and the rates of upward flow which can safely be used are not great enough to effectively break up the film overlying the surface of the sand; the practice has been abandoned.

Sand Washing. Washing of sand in place has not yet been introduced in the Hartford plant, although the purchase of a mechanical washer of this type has been recommended. The present sand-washing equipment, consisting of a battery of four Nichols sand washers, is permanently housed on top of the old filter beds, adjacent to the sand court.

Briefly, the present method of sand washing consists in scraping off the top layer of dirty sand, shovelling it into piles from which it is wheeled and dumped into a box-type ejector. A jet of water passing through this ejector carries the sand through a combination hose-and-pipe line out of the filter beds, across the top of the filters to the four Nichols sand washers. The washed sand is discharged from these machines into a box ejector and thence through a hose line to the sand court where it is stored for future use.

Water for sand washing is delivered to each filter bed through a permanent installation of 4-in. galvanized wrought-iron piping, fed from a central pumping plant located in the office building. The pumping equipment consists of a three-stage centrifugal pump with a rated capacity of 500 g.p.m. with a pump pressure of 175 lb. per sq. in. As ordinarily operated, pumping rates average about 400 g.p.m. with a pump pressure of 160 lb. per sq. in. Of the amount pumped, about 100 g.p.m. are used at the sand-washing machines and sand court, leaving 300 g.p.m. to be divided between the two ejectors in use in the filter bed.

These ejectors work simultaneously in different parts of a bed. Each ejector is connected to the wash-water piping by a length of 4-in. hose; a similar arrangement at the discharge side connects with a temporary

line of 4-in. spiral flanged steel riveted pipe, laid on top of the filter beds and extending across them to the sand-washing machines. These pipe lines vary in length from 150 to 500 ft., depending on the distance from the bed being washed to the washing machines. Each pipe line terminates in a siamese connection and feeds two washing machines. This division of flow from the pipe line, reduces the flow into each machine to such an extent that the upward velocities are not sufficient to cause any appreciable loss in sand.

Water is delivered to the ejectors in the beds at a pressure of 100 lb. per sq. in., giving a jet velocity of about 150 ft. per sec. A total crew of twelve men is used for sand washing. Each ejector requires five men; two men shovelling, two wheeling and one feeding the ejector; in addition two men operate the four washing machines. Two inches of sand are ordinarily removed at each washing, corresponding to 140 cu. yd. of sand on a half-acre bed and 200 cu. yd. on a three-quarter acre bed. The four washing machines, as operated, each wash sand at a rate of $2\frac{1}{2}$ cu. yd. per hour, a plant rate of 10 cu. yd. per hour, using an average of 1 800 gal. of water per cu. yd. of sand washed.

In connection with sand washing, considerable experimental work has been done using different types of ejector throats, sizes of jets, and working pressures. These experiments have resulted in the adoption of an ejector with a $\frac{5}{8}$-in. jet, a $1\frac{1}{4}$-in. cast-iron Venturi-type throat and an operating pressure of about 100 lb. per sq. in. at the ejector.

Resanding. When repeated washings have reduced the depth of sand in a bed to approximately 20 in., it is resanded. Prior to resanding, however, two more washings are made. Two inches of sand are removed and washed in the first washing; in the second, one inch is taken. Following these two washings, the top 12 in. of sand are thoroughly spaded and loosened up to remove hard spots.

In resanding operations, sand is picked up from the sand court by a special type of ejector and fed into the washing machines. The washing machines discharge into a box-type ejector which delivers the sand through a single spiral-riveted steel pipe, temporarily laid over the top of the filters and terminating in a hose line passing down through a filter manhole, into the bed which has previously been refilled with filtered water to the elevation to which resanding is to be carried. Resanding is done under water by the so-called Washington method. The discharge end of the sand line, consisting of a short length of 4-in. pipe, is permanently attached to a flat-bottomed boat, and the outlet is set just below the water surface and forms an angle of 45 degrees with it. By moving the boat slowly back and forth the discharged sand gradually builds up a bank to the surface of the water, and the edge of the bank is slowly extended over the bed. The velocity of the sand and the angle at which it is discharged prevent the settlement of sediment on the sand surface. One man maneuvers the boat; another keeps the level of the sand to a true grade. The level of

water in the bed is kept at a constant elevation by cracking the sump-well waste-gate just enough to compensate for the water being brought into the bed through the sand line. It is possible to resand an entire bed with but two changes of the sand line on top of the filters.

The two ejectors which pick the sand up at the sand court are of the self-burying type. To insure a steady supply of sand, however, a man is stationed at the sand court where, by means of a hose stream, a constant stream of sand is washed down to the ejectors. For resanding, the operating force consists of five men, one at the sand court, two at the washing machines and two in the bed placing the sand.

The ejector taking the discharge from the washing machines has a jet with a throat $\frac{3}{16}$ in. in diameter. The pressure at the inlet side averages 100 lb. per sq. in., giving a jet velocity of 125 ft. per sec., and a velocity in the sand line of 5 ft. per sec. Beds are resanded at an average rate of 10 cu. yd. per hour.

The 1930 records show 1 bed resanded, 21 washed and 101 raked. The record of former years is shown in the following table.

FILTER WASHINGS AND RAKINGS.

Year.	Beds Resanded.	Beds Washed.	Beds Raked.
1924	2	24	111
1925	2	23	111
1926	2	14	79
1927	3	19	88
1928	1	18	102
1929	3	23	98
1930	1	21	101

Operating Costs. Total operating and maintenance costs for 1930 amounted to $20 636 of which $2 051 were chargeable to power-plant operation and maintenance. The average cost of filtering water during 1930 amounted to $3.03 per m.g. Operating costs for the past eight years are given in the following table.

OPERATING COSTS.

	Labor.	Materials.	Total.	Totals grouped.
Filters:				
Operation	$15 886	1 884	17 770	
Maintenance	169	646	815	$18 586
Power Plant:				
Operation	1 400	14	1 414	
Maintenance	0	637	637	2 051
				$20 636

1929	$21 495
1928	18 867
1927	22 364

	PER MILLION GALLONS.							
	1930.	1929.	1928.	1927.	1926.	1925.	1924.	1923.
Filters:								
Operation and Maintenance	2.73	2.90	2.54½	3.12½	3.07	3.09¼	3.07	2.93
Power Plant:								
Operation and Maintenance	.30	.41	.36	.38	.46	.51½	.67½	.89¼
	3.03	3.31	2.90½	3.50½	3.53	3.61	3.74½	3.82¼

Consumption, m.g.: 1930, 6799; 1929, 6486; 1928, 6489; 1927, 6387; 1926, 6045; 1925, 5872; 1924, 5898; 1923, 5762.

A total of 5 090 cu. yd. of sand was handled in 1930 at a total cost of $3 263. Of the amount handled, 1 120 cu. yd. were used in resanding and 3 970 in washing.

The cost of washing sand was $0.74 per cu. yd., and the cost of resanding amounted to $0.30 per cu. yd.

The following table gives the cost of handling sand for the last seven years.

SAND HANDLING COSTS.

Labor Only.	1930.	1929.	1928.	1927.	1926.	1925.	1924.
Total Cu. Yd. of sand handled....	5 090	6 560	4 046	6 282	3 809	5 844	5 700
Cost.....	$3 263	$4 165	$2 969	$4 142	$3 860	$5 891	$5 391
Cost per Cu. Yd...	0.641	0.635	0.734	0.659	1.014	1.008	0.95
Total Cu. Yd. re-sanded.....	1 120	3 080	980	3 150	1 360	2 135	2 560
Cost.....	$335	$1 120	$520	$1 191	$1 137	$1 736	$1 752
Cost per Cu. Yd...	0.299	0.364	0.53	0.378	0.836	0.81	0.68
Total Cu. Yd. washed.....	3 970	3 480	3 066	3 132	2 449	3 709	3 141
Cost.....	$2 928	$3 045	$2 449	$2 951	$2 723	$4 155	$3 640
Cost per Cu. Yd...	0.737	0.875	0.799	0.941	1.112	1.112	1.16

None of costs here given include depreciation on plant or interest on the capital invested.

PURIFICATION PERFORMANCE.

The average color of raw water received at the filters during 1930 was 17 p.p.m.; filtered water delivered to the consumer averaged 10.3 p.p.m. color, a percentage reduction of 39.4. The percentage removal of bacteria was about 94, the raw-water count being 99 and the filtered water containing only six. The effect of filtration on color and bacteria is shown in the accompanying table.

The entire design and construction of the filter plant, as well as the development of the Nepaug source of supply, was carried out under the personal direction and supervision of Caleb M. Saville, Manager and Chief Engineer of the Water Bureau of the Metropolitan District of Hartford County.

The success which has attended the operation of the filter plant is due very largely to the untiring efforts of its superintendent and the splendid spirit of team work which he has developed among those with whom he is associated.

Monthly Summary of Daily Examinations of Water Supplied to City, 1930.

	Raw Water.			Colon Bacilli. *	Filtered Water.						Colon Bacilli.		Chlorine.	Color.		Per cent. Color Removal.
	Bacteria per cc. at 20° C.			Times in 10 cc. or less.	Bacteria per cc. at 20° C.			Bacteria per cc. at 37½° C.			Times in 10 cc. or less.		p.p.m.	p.p.m.		
	Max.	Min.	Aver.		Max.	Min.	Aver.	Max.	Min.	Aver.	Presumptive Test.	Differentiation Test.		Raw.	Filt.	
January	100	25	51	7	10	2	5	21	2	8	1	0	..	24	15	37.5
February	75	20	42	4	10	2	5	13	1	7	3	0	..	24	15	37.5
March	75	18	38	7	18	2	5	25	2	7	1	0	..	18	12	33.3
April	60	25	35	7	7	1	3	30	1	8	0	0	..	20	13	35.0
May	75	18	32	6	18	2	5	10	1	5	1	0	..	18	12	33.3
June	75	17	31	8	10	1	4	14	2	6	0	0	..	15	9	40.0
July	150	3	39	10	22	2	8	100	1	14	5	2	..	13	8	38.4
August	1 500	25	262	1	28	1	12	27	1	7	3	0	..	12	7	41.7
September	6 500	10	500	2	15	3	7	27	1	5	0	0	..	13	7	46.1
October	300	15	95	4	14	1	8	48	1	8	3	1	..	17	9	47.0
November	180	4	32	2	15	1	4	7	1	19	2	0	..	17	9	47.0
December	125	6	24	1	11	1	5	13	1	3	1	0	..	13	8	38.5
Average	..	..	99	..	..	..	6	..	..	8	..	..	..	17	10.3	39.4

*All figures in this column are for presumptive test.

PROCEEDINGS.

FIFTIETH ANNUAL CONVENTION.

BOSTON, MASSACHUSETTS.

September 29 to October 2, 1931.

The following is a synopsis of such parts of the proceedings of the Fiftieth Convention as appear to be of value for the record.

The Fiftieth Annual Convention of the NEW ENGLAND WATER WORKS ASSOCIATION was held at Boston, Mass., September 29 to October 2, 1931.

The sessions of the convention were held on the mezzanine of Hotel Statler, accommodations for the exhibits of Associates also being provided on the floor.

President George H. Finneran presided at the meetings.

TUESDAY, SEPTEMBER 29.

Morning Session.

THE PRESIDENT. It is my privilege and pleasure to declare the Fiftieth Annual Convention of the NEW ENGLAND WATER WORKS ASSOCIATION opened.

ADMINISTRATIVE REPORTS.

The Annual Reports of the Secretary, Treasurer, and Editor were submitted by Frank J. Gifford, Albert L. Sawyer, and Gordon M. Fair, respectively. (See page 396.)

The Report of the Finance Committee was read by the Secretary. (See page 402.)

Upon motion from the floor, duly seconded, it was voted to accept these reports and place them on file.

AMENDMENT TO CONSTITUTION.

THE PRESIDENT. I am going to submit to you a petition for an amendment to the Constitution which has been received by the Executive Committee, and upon vote of that Committee recommended for submission to the Association for acceptance or rejection.

Section 1 of Article V of the Constitution is hereby amended by substituting therefor the following:

Section 1. The officers of the Association to be elected in September 1932, shall be a President, two Vice-Presidents, three Directors and a Treasurer. The President, one Vice-President, one Director and the

Treasurer shall be elected for terms of one year each, and one Vice-President and one Director for a term of two years each, and one Director for a term of three years. Thereafter there shall be elected each year a President and a Treasurer with terms of one year each, a Vice-President for a term of two years and a Director for a term of three years. Beginning in September 1932, the terms of the elective officers shall begin at the close of the Annual Convention and shall continue until a successor is elected.

Under the present rule the terms of two directors expire every year. One only of these two may then be elected vice-president for a two-year term. Because of this, the services of a desirable executive are frequently lost to the Association. The Nominating Committee, furthermore, is compelled to choose between two equally valuable men for advancement.

Under the proposed amendment the term of only one director will expire each year after 1932, and only one director will be elected each year. Therefore, it will be possible to elect the retiring director as vice-president for a term of two years.

JOHN C. CHASE.* Mr. President, this report seems to be in conformity with what is considered the best practice in associations of this nature. I think it is most admirably conceived, and I move that the proposed amendment be adopted.

(*The motion is duly seconded.*)

THE PRESIDENT. The Constitution requires a two-thirds majority of those voting. Will those in favor of the amendment rise and stand so that they can be counted. (*A rising vote is taken.*) The amendment has been carried by a two-thirds vote.

Award of Dexter Brackett Memorial Medal.

THE PRESIDENT. At a meeting of this Association on September 13, 1916, Mr. Charles W. Sherman, one of our past presidents, and a much esteemed member, made a motion, which was adopted, that the Executive Committee shall annually appoint three members of the Association, who shall constitute a committee to recommend the award of a bronze medal to the member who presented during the preceding year a paper judged to be the most meritorious, bearing in mind its applicability to general water-works problems. This medal was to perpetuate the memory of Dexter Brackett, who was president of the Association during the year 1889–1890, and who had a large share in making the Association what it is.

I should like to quote Mr. Sherman's remarks in connection with the presentation of the medal at one of our conventions, held in 1928. Mr. Sherman said:

As I was a member of the original committee that solicited the fund to establish this medal and to secure the designs, and that had the first medal struck off, it is not too much of a burden, as it might be, to take

*Derry, N. H.

over this presentation, because I am always very much interested in the award, and especially interested, of course, in its being made along the lines intended by the original committee, which we believed and still believe, was the right line for the perpetuation of the ideals of Dexter Brackett. He was one of the most influential members of this Association, and one who did perhaps as much for it as any single man. Mr. Brackett was especially interested in making the Association a practical organization, which would advance Water Works knowledge, and the intent of the award of this medal was that it should be given for the paper which did the most, from among all the papers published during the year in the JOURNAL, to advance Water Works knowledge.

This year a Committee was appointed, consisting of Karl R. Kennison as Chairman, Lewis D. Thorpe and David A. Heffernan, to recommend the award of the medal. This Committee recommended, and the Executive Committee approved, that the award be made to Frank C. Hale for his paper entitled, "Control of Microscopic Organisms in Public Water Supplies, with Particular Reference to New York City." This paper was published in Volume 44, No. 3, of the JOURNAL.

Will Mr. Hale please come to the platform?

(*Mr. Hale comes to the platform.*)

For the benefit of those who may not know Mr. Hale, and are not familiar with his work, I should like to say that he is engaged with the Department of Water Supply, Gas and Electricity of New York City. He is and has been since 1913, Director of Laboratories in that department.

At present there are three laboratories, Mount Prospect, in the city, Mount Kisco on the Croton water shed, and Ashokan on the Catskill water shed. A force of twenty-eight men is employed. About 20 000 samples are analyzed yearly. The water shed area is over 1 100 sq. miles and the daily consumption about 900 m.g.d. The laboratory division has supervision in large measure of the quality of the water supply and gives expert advice as to treatment. It has analytical control of fifty chlorination plants, of eight sewage-disposal plants on the water sheds, of several iron-removal plants, of turbidity removal, of microscopic organisms, and so forth. The typhoid death rate in New York City has decreased from about 20 to less than 1 per 100 000 population since the establishment of this laboratory.

Mr. Hale has membership in many water works, engineering, chemical and public health societies, and is the author of about sixty research papers published in various scientific journals, and many contributions to various books on chemical practice.

This is not the first time he has been similarly honored, as in 1919 he was awarded a prize by the Municipal Engineers of New York for the best paper presented that year.

It gives me great pleasure to present this medal to you, Mr. Hale (*handing medal to Mr. Hale*).

FRANK C. HALE. I thank you, President Finneran. I shall hold this medal in the highest esteem.

I should like to make just one remark about the editorial policy of the Association, and that is that you print papers in full, which is not always the case. (*Applause.*)

CLOSING OF POLLS.

THE PRESIDENT. The Constitution requires that the polls be closed one hour after the opening of the Convention. This time was provided to give anybody who had not already voted for the new officers of the Association an opportunity to do so. The time having elapsed, I declare the polls closed.

Messrs. Arthur C. King, W. Guy Classon and Horace J. Cook are appointed tellers to collect, sort and count the ballots and report at our banquet at 8.00 P.M. on Thursday night.

APPOINTMENT OF COMMITTEE ON USE OF FIXTURES AND APPLIANCES.

GEORGE A. KING.* Mr. President, I was discussing this morning with a prominent member of this Association the effect of some of the modern appliances which are being installed upon our fixtures and the control which the water department have over them. He suggested,— and I believe he is right,— that we should appoint a committee of five which should consider what appliances are being used, the effect they have upon our water systems, and to what extent we may control them.

I therefore move that a committee of five be appointed to consider and report upon the various fixtures and appliances which are or may be used on water services, and the possible effect of their use upon the water systems, and also to report upon the extent to which water departments may control the kind and design of such fixtures and the manner of their use.

(*The motion is seconded and carried.*)

TUESDAY, SEPTEMBER 29.

Afternoon Session.

Secretary Gifford announced the election by the Executive Committee of the following new members and associates:

Members: Harold E. Weeks, Attorney-at-Law, Fairfield, Me.; Luther E. Cotton, Boston, Mass.; Horace R. Nash, Norwalk, Conn.; Benjamin G. Sargent, Natick, Mass.; John E. Landers, East Hartford, Conn.; Joseph Landers, Braintree, Mass.; Alan L. Pratt, Hanson, Mass.; Dana M. Pratt, Hanson, Mass.; Harry Manson, Lebanon, N. H.; William Paterson,

*Superintendent of Water Works, Taunton, Mass.

London, Eng.; Daniel A. Cashman, Haverhill, Mass.; Oscar J. Scammon, Hampton, N. H.

Associates: Sentry Manufacturing Company, Medford, Mass.; Revere Copper & Brass, Inc., Taunton, Mass.; Inertol Co., Inc., New York City.

Corporate Member: Lawrence Water Department, Lawrence, Mass.

Historical Papers.

A paper "History of the New England Water Works Association," was read by Charles W. Sherman, of Metcalf and Eddy, Engineers, Boston, Mass.

ELECTION OF CHARLES W. SHERMAN TO HONORARY MEMBERSHIP.

THE PRESIDENT. It is customary for this Association from time to time to confer honorary membership on one of its members of acknowledged eminence in some branch of water-works or engineering. Under the provisions of the Constitution, this year ten prominent members petitioned the Executive Committee to elect by unanimous vote Mr. Charles W. Sherman to honorary membership. (*Applause.*) It is needless to say that the unanimous vote was registered.

Mr. Sherman joined the Association in 1897, was elected President in 1921, was awarded the Dexter Brackett Memorial Medal in 1922. His services throughout all those years of membership have been of greatest importance to the Association. His presence or his name have always awakened in my mind the thought that he is and has been one of our most valued members. His sincerity and earnestness, as far as the interests of the Association are concerned, have always impressed me, as has also his courteous and kindly manner.

I think I am speaking for all when I say it gives us great pleasure to elect Mr. Sherman to our Hall of Fame. I should like, however, to have some member who has had more intimate contact with Mr. Sherman than myself professionally, socially, and in a business way, to say a few words to Mr. Sherman and tell him and the members what he knows and thinks of him. I am going to call on Mr. Saville.

Mr. Saville, will you kindly escort Mr. Sherman to the chair?

(*Applause, during which Mr. Saville escorts Mr. Sherman to the chair.*)

CALEB M. SAVILLE.* Mr. President and Gentlemen: Many years ago I first met Mr. Sherman at the beginnings of the Metropolitan Water Works System. The acquaintanceship then begun ripened into friendship while Mr. Sherman advanced in his professional life to very near the top. I am glad and consider myself fortunate to have known him so well.

In his public and professional life Mr. Sherman has also demonstrated his personal character and ability as a man. From principal assistant,

*Manager and Chief Engineer, Board of Water Commissioners, Hartford, Conn.

with Mr. Desmond FitzGerald, through similar contact with Mr. F. P. Stearns, through his position with Leonard Metcalf, and finally full partnership in the firm of Metcalf and Eddy, Mr. Sherman has demonstrated his professional ability, especially in water-works lines. As editor of the NEW ENGLAND WATER WORKS JOURNAL, and in many other ways, Mr. Sherman has been one of the greatest helps to this Association in carrying on the banner of those earlier founders.

It gives me great pleasure to present to you today my friend, Mr. Charles W. Sherman, and to tell you that in electing him to honorary membership in this Association, this Association has greatly honored itself. (*Applause.*)

MR. SHERMAN. Mr. President, Mr. Saville, and Gentlemen: I only wish I could believe that I deserve all the nice things which have just been said about me.

I plead guilty to having given considerable time to the service of the Association. It has been a labor of love, and I have been more than repaid for all I have done for the Association.

I am especially glad that Mr. Saville did not see fit to say everything he knew about me.

I appreciate this honor more than I can say. It is a very real honor, and I know of nothing that I would appreciate any higher. I thank you. (*Applause.*)

The following papers were read:

"The Boston Water Works," by Frank A. McInnes, Consulting Engineer, Boston.

"The Relation of the Metropolitan Water Board to its Member Communities," by David A. Heffernan, Superintendent of Water Service, Milton, Mass. Theodore L. Bristol discussed the paper.

"Trend of Water Works Practice in the Past Fifty Years," by Caleb M. Saville, Manager and Chief Engineer, Water Bureau, Hartford, Conn.

The President's Reception and Dance was held in the Salle Moderne of the Statler Hotel during the evening.

WEDNESDAY, SEPTEMBER 30.

Superintendents' Day.

From 9.00 A.M. to 11.00 A.M., the presiding officer was W. A. MacKenzie, Superintendent of Water Works, Wallingford, Conn. The general subject of this part of the meeting was "Emergency Problems of the Water Works Superintendent." The following papers were read:

"Chlorination for Special and Emergency Purposes," by J. D. MacMahon of the Mathieson Alkali Works, Niagara Falls, N. Y.

"Disinfection of Water Mains," by Harry U. Fuller, Chief Engineer, Portland Water District, Portland, Me.

"Water Works Emergencies from the Health Standpoint," by Warren J. Scott, Chief Engineer, Connecticut State Department of Health, Hartford, Conn.

"Provisions for Meeting Emergencies resulting from breaks in Water Mains," by Theodore L. Bristol, President of Ansonia Water Company, Ansonia, Conn.

"Construction Layouts and Location of Gates Found of Value in Emergencies," by Samuel H. MacKenzie, Engineer and Superintendent, Southington Water Department, and Terryville Water Department, Southington, Conn.

These papers were discussed by Harold W. Griswold, Samuel H. MacKenzie, Roger W. Esty, Francis H. Kingsbury, Linn H. Enslow, Theodore L. Bristol, David A. Heffernan, Rupert A. Wigmore, George F. Merrill, Frederick O. A. Almquist, Jr., and Henry T. Gidley.

At 11.20 A.M., H. J. Cook, Superintendent of Water District, Auburn, Me., took the chair. The general subject of this session was "Tuberculation of Mains and Services."

The introductory paper on "Tuberculation of Mains as Affected by Bacteria," prepared by H. G. Reddick and S. E. Linderman, United States Pipe and Foundry Company, Burlington, N. J., was read by Mr. Linderman. The paper was discussed by H. G. Reddick, Malcolm Pirnie, Elwood L. Bean, Stephen H. Taylor, John T. Robertson, Roger W. Esty, Sidney S. Anthony, and Samuel H. MacKenzie.

The discussion of the general subject of Tuberculation of Mains was continued at 2.00 P.M., being participated in by David A. Heffernan, Henry T. Gidley, Malcolm Pirnie, Charles W. Sherman, Charles W. Mowry, James W. Graham, Roger W. Esty, Sidney S. Anthony, W. C. Hawley, Edwin H. Arnold, Herbert C. Crowell, and Caleb M. Saville.

At 3.00 P.M., Stephen H. Taylor, Superintendent of Water Works, New Bedford, Mass., took the chair. The general subject of the program was "Relation of Water Works to Fire Fighting."

An introductory paper "Water Consumption during Fires," was read by Charles W. Mowry, Manager, Inspection Department, Associated Factory Mutual Fire Insurance Companies, Boston, Mass.

Edward E. Williamson, Superintendent of Maintenance Division, Boston Fire Department, explained the equipment and methods of handling fires in Boston.

The general subject was discussed by J. Walter Ackermann, Frank A. McInnes, George A. King, Sidney S. Anthony, Charles W. Sherman, James W. Graham, David A. Heffernan, John S. Caldwell, David E. Moulton, G. A. Griffin, Caleb M. Saville, Rupert A. Wigmore, and W. C. Hawley.

Resolutions of Sympathy.

PATRICK GEAR.* I move that the officers of this Association prepare a resolution and send it with flowers to the family of our honored member and good friend, Edward W. Quinn, former Mayor of Cambridge, who died this morning, expressing the sympathy of the members of the Association in their bereavement.

(*The motion is carried by a rising vote.*)

CHAIRMAN TAYLOR. Mr. Lockwood has told me that Mr. Gibson of Charleston, S. C., has just lost a son in an airplane accident in Florida. He suggests that a resolution of sympathy from this organization would be very much appreciated and very proper.

(*The motion is duly seconded and carried.*)

Demonstration of High-pressure Fire System.

Through the courtesy of Fire Commissioner Edward F. McLaughlin, a demonstration was given by the Boston Fire Department of their High Pressure Fire Fighting System, after the close of the afternoon session. Several pumpers and two fire boats participated. The demonstration started with a pressure of 150 lb. per sq. in., which was increased to 220 lb. per sq. in., the maximum discharge being 30 000 g.p.m. The High Pressure Fire Service Pumping Station on Atlantic Avenue was also open for inspection.

During the evening a smoker was held in the ballroom of the Hotel Statler. An excellent entertainment was provided by courtesy of the Water Works Manufacturers Association.

THURSDAY, OCTOBER 1.

Morning Session.

President Finneran in the chair.

A paper "The Development of Water Purification," was read by Robert Spurr Weston, Consulting Engineer, Boston.

THE PRESIDENT. I am going to ask Mr. Weston to take the chair for the remainder of this session.

(*Robert Spurr Weston takes the chair.*)

Symposium on Water Purification in New England.

The following papers were read:

"Operating Experiences at the Cambridge, Massachusetts, Filtration Plant," by Melville C. Whipple, Assistant Professor of Sanitary Chemistry,

*Superintendent, Water Works, Holyoke, Mass.

Harvard Engineering School, Supervising Chemist, Cambridge Water Board, and Fred E. Smith, Chemist, Cambridge Water Purification Works, Cambridge, Mass. (Read by Mr. Smith.) Warren J. Scott and Malcolm Pirnie discussed the paper.

"Five Years' Water Purification at Providence," by E. L. Bean, Chemist, Water Works, Providence, R. I. This paper was discussed by Malcolm Pirnie.

"Water Filtration at Hartford," by W. A. Gentner, Office Engineer, Water Bureau, Hartford, Conn. Caleb M. Saville and A. W. Brosmith added their remarks to Mr. Gentner's paper.

"Operation of the Greenwich Filter Plant," by H. C. Chandler, Chemist, Greenwich Water Company, Greenwich, Conn.

Resolution in Re Unemployment Relief.

MALCOLM PIRNIE.* The Executive Committee of this Association felt, in view of the National emergency existing at the present time in the form of unemployment, that this Association should not leave this Convention without taking some official notice of it and offering, if possible, some suggestion for relief. Your Executive Committee appointed a Committee to draw up the resolution, which I will read. It is of necessity long, so that I will ask you to listen through it for the thread of the idea.

WHEREAS, steps are now being taken in many states to raise and appropriate funds for the relief of unemployment, and

WHEREAS, such relief may take the form either of a dole or of a compensation for time and labor given to the state or community that provides the funds, and

WHEREAS, it is generally agreed that the dole is not desired either by the unemployed or by those who would be taxed to raise the funds, and

WHEREAS, in most urban communities there exist needs for additional public facilities, to provide which would produce employment for many if not for all who are now unemployed, and

WHEREAS, the present financial burden on real estate is so great that it would be unwise, if not impracticable to authorize expenditures for new facilities which would be an added lien on real estate, and

WHEREAS, water works, gas and electric properties are revenue-producing and are self-supporting with proper rates in force, water works being largely municipally owned, and

WHEREAS, water-works distribution-systems are universally in need of reinforcement, particularly in the residential sections and many communities need additional water-supply works or water-purification works, and

WHEREAS, privately owned water, gas and electric properties in various communities are in need of improvements to provide satisfactory service, money for which can be secured if the rates in force are equitable, and

WHEREAS, at present both materials and money can be secured considerably below normal costs, making this an ideal time for investment in needed public works.

*Consulting Engineer, New York, N. Y.

BE IT THEREFORE RESOLVED, that the NEW ENGLAND WATER WORKS ASSOCIATION assembled in its Fiftieth Annual Convention urges that the funds to be expended in unemployment relief be applied to the provision of needed water works and other revenue-producing public works substantially in accordance with the following program:

Proposal to Provide Useful Work Instead of a Wasteful Dole.

Call upon each of the urban communities in the political subdivisions charged with the administration of unemployment relief funds to take care of its own unemployed.

For example, the urban population of New York State is more than 10 000 000, and it is estimated that all unemployment is in urban communities. Instead of raising $20 000 000, as authorized, through taxes on incomes in one year, raise $7 000 000 per year for three successive years, amounting to 70 cents per urban capita. Notify all communities, having populations of 1 000 or more, that 70 cents per capita will be paid to them from the unemployment relief fund to be used to pay interest on bonds for improvements to revenue-producing properties, for a period of three years. After this, the community will assume its own interest payments and presumably at the end of the first five years will also assume its own amortization of bonds issued.

Seventy cents per capita is the interest at 4½ per cent. on $15.50 per capita. This means that the interest for three years will be guaranteed to urban communities in the state on a total of $155 000 000 worth of construction work applied to revenue-producing properties. It is estimated that more than half of the proceeds from such bond issues would be paid to local labor in the communities and that the balance would provide employment in cement mills, foundries, gravel pits, etc.

The above figures are based on average performance by all urban communities. Undoubtedly there will be some communities which have already made all needed improvements to their revenue-producing properties, and others which are in immediate need of improvements considerably in excess of the average. Payments from the Fund should be made annually up to a maximum of 70 cents per capita for all new revenue-producing works initiated within the next sixty days. Such money as remains in the Fund due to works below the average in cost should then be distributed among those communities which initiate work in excess of the average and in proportion to the amount of work in such excess.

General Benefits.

The principal result of such a program will be to initiate at least $150 000 000 worth of work to give employment, instead of attempting to distribute $20 000 000 equitably among 900 000 unemployed. In the production of this work the burden upon taxpayers would be reduced to one-third of that proposed in the first year and all money so paid would

be invested in revenue-producing properties instead of being dissipated in the form of a dole. In these circumstances, money paid by the taxpayers would ultimately be returned with interest to the population of the state as a whole, through the earnings of the utility properties in which it had been invested.

None of the expenditures would add to the present burden on real estate. All capital charges for permanent improvements to the utilities would be borne after three years by those using them through rates paid for the service taken.

Under present conditions, the main obstacle to raising money for water-works improvements is the difficulty of paying the interest on their cost during the first few years, while the business is growing to a paying use of the new facilities. This difficulty would be largely removed if interest were paid during these years. The fact that the community ultimately would assume the interest charges and amortization would serve as a check on extravagant improvements which are not really justified by the need for them.

What this means on the average to communities of various sizes in the state of New York is indicated in the following table:

Population, in thousands.	Number of Communities.	Average Value of Construction in each Community.	Total Value of Construction.
1 to 2.5	146	$30 000	$4 380 000
2.5 to 5.0	46	60 000	2 760 000
5.0 to 10.0	41	120 000	4 920 000
10.0 to 25.0	47	300 000	14 100 000
25.0 to 600.0	22	1 100 000	24 200 000
New York City	1	105 000 000	105 000 000
		Total	$155 360 000

AND BE IT FURTHERMORE RESOLVED: that a copy of these resolutions be forwarded by the Secretary of the Association to the Governors of the several states and to the executive officers of any other political subdivisions known to be contemplating the administration of unemployment relief funds.

(*Signed*) MALCOLM PIRNIE, *Chairman.*
STEPHEN H. TAYLOR,
GEORGE C. BREHM,
Committee.

After discussion the report of the Committee was accepted and the resolution adopted.

THURSDAY, OCTOBER 1.

Afternoon Session.

THE PRESIDENT. I am going to call upon Mr. Harrison P. Eddy to conduct the meeting.

(*Harrison P. Eddy takes the chair.*)

The following papers were read:

"The Law of Interstate Waters and its Application in the Case of the Delaware River," by Thaddeus Merriman, Chief Engineer, Board of Water Supply, New York, N. Y.

"Diversion of Interstate Waters for Domestic Water Supply — Litigation and United States Supreme Court Decision in Case of Connecticut *v.* Massachusetts," by Frank E. Winsor, Chief Engineer, Metropolitan District Water Supply Commission, Boston, Mass.

These papers were discussed by H. K. Barrows, James F. Sanborn, H. T. Critchlow, Morris R. Sherrerd, Ezra B. Whitman, Nathan B. Jacobs and X. H. Goodnough.

Written discussions of these papers were also submitted by the following: Robert Spurr Weston, W. L. Stevenson, Charles E. Ryder, and Solomon M. Swaab.

THURSDAY, OCTOBER 1.

Evening Session.

By courtesy of the Water Works Manufacturers Association, a banquet was given in the ballroom of the Hotel Statler, after which the closing business session of the Convention was held.

Report of Tellers of Election.

Total number of ballots cast	274
President.	
GEORGE C. BREHM	265
SCATTERING	1
BLANK	8
Vice-President.	
E. SHERMAN CHASE	271
BLANK	3
Directors.	
HARRY U. FULLER	266
BLANK	8
FRANK E. WATERMAN	268
BLANK	6
Treasurer.	
ALBERT L. SAWYER	273

(*Signed*) ARTHUR C. KING, *Chairman.*
W. G. CLASSON,
HORACE J. COOK.

THE PRESIDENT. I am sure that it will give the members of the Association much pleasure to hear a few words from our newly elected President, George C. Brehm. (*Applause.*)

GEORGE C. BREHM. Mr. Chairman, Honorable Charles R. Gow, members of the NEW ENGLAND WATER WORKS ASSOCIATION, Ladies and Gentlemen: No one can be elected president of an Association that has had such a high standard as the NEW ENGLAND WATER WORKS ASSOCIATION without realizing what an honor the members have shown him in electing him to that office. In assuming the presidency I am well aware of the responsibilities that go with it, and I appreciate very much the obligations that I am to fulfill. I know that I have a task ahead of me to fulfill the duties that go with the presidency of this Association as well as the past presidents have done. It is going to be a big job. But I want to assure you at this time that I shall do everything in my power to maintain the high efficiency and the high standard of this Association, and I know, in order to help me realize this ambition, the members will give me their usual untiring coöperation. When I say that I thank you, please believe me to be sincere. I thank you very much. (*Applause.*)

THE PRESIDENT. I want to express the thanks of the Association to all those who have made the convention a success. Particularly to the Fire Commissioner of Boston, who gave us a wonderful exhibition of the high-pressure fire system on Wednesday evening, to the Manufacturers Association, whose exhibits have been so instructive and interesting, to their entertainment committee, who have made the Convention so enjoyable, also to our chairman of the Convention Committee, Mr. Bingham, and the other gentlemen who have served on the various committees, especially our Program Committee, composed of Messrs. Chase, McInnes, and Esty.

We had hoped to have with us tonight his Excellency, Governor Ely, but engagements previously made have prevented his presence here. However, he has appointed to represent him here tonight the Chief Engineer of the Metropolitan District Water Supply Commission. As you know, this Commission is engaged in providing the Metropolitan District with a safe and adequate supply of water, not only for the present time but for years to come. The Chief Engineer of this Commission is one of our members, one of our past presidents, and we shall be very glad to hear from him. I want to present Mr. Frank E. Winsor. (*Applause.*)

GREETINGS FROM THE COMMONWEALTH.

BY FRANK E. WINSOR.*

MR. WINSOR. Mr. President, Honored Guests of the Association, Members of the NEW ENGLAND WATER WORKS ASSOCIATION, Ladies and Gentlemen: Four years ago it was my privilege to occupy the position at

*Chief Engineer, Metropolitan District Water Supply Commission.

this table now occupied by President Finneran. You had charity enough to get along with me for a year, and I think that you had every reason to expect that I had been retired. I am going to take this occasion to congratulate President Finneran on the success of this Fiftieth Anniversary Convention, which I believe to be the best convention of this Association that I have ever attended, and I think it is probably the best convention that this Association has ever held.

In the moment that is allotted to me I have been asked to express to you the regards of his Excellency Governor Ely. A long-standing engagement has taken him away from the city and prevented him from personally extending to you the greetings of the Commonwealth. It is a plessure for me to assure you that the Governor fully appreciates the work which you water-works men are doing in your respective communities in supplying to those communities that one commodity without which life could not exist. The Governor is also not unmindful of the work which has been done by this Association, of its accomplishments during the past fifty years, of the influence which it has exerted in bringing together men from the various parts of the state and country, and establishing a community of interests and an *esprit de corps* in the water-works profession which is in no small degree responsible for the present state of advancement in water-works practice. It is a privilege and a pleasure to extend to you in his behalf the greetings of the Commonwealth, and to express also his best wishes for the continued prosperity and the continuance of the wonderful achievements of the NEW ENGLAND WATER WORKS ASSOCIATION. (*Applause.*)

THE PRESIDENT. Boston, as the largest city in this state, and, as it is sometimes called, the capital of New England, has a big interest in matters of water supply. The total of its sales in the city of Boston amounts at the present time to about $5 000 000 yearly, over half of which sum is turned over to the state to pay the expenses of the Metropolitan Water Works. The responsibility for collecting the funds to pay this huge assessment, together with an almost similar amount which is used to defray the expense of running the water-works of the city itself, is one of the many duties which devolve upon the Mayor of the city. How well he has done in this matter, as in many others, is attested by the fact that the electorate has put him in office for the third time, for a period of four years each. That is surely a testimonial to his ability and success in administering the affairs of the city.

We had hoped to have the Mayor here tonight in person, but he is a busy man, very much in demand, and at the last moment he sent as his representative Mr. William G. O'Hare, Commissioner of Penal Institutions of the city of Boston. We shall be glad to hear from Mr. O'Hare. (*Applause.*)

Greetings from the City of Boston.

BY WILLIAM G. O'HARE.*

Mr. O'Hare. Mr. President, Invited Guests, Ladies and Gentlemen of the New England Water Works Association: Every man and every woman in New England always has the thought brought home to him or her in some way or other of the wonderful bounty of Almighty Providence in giving to New England the best natural water supplies in the world. Whether it be the old well or the pump in the kitchen, whether it be the privately operated company or the municipally owned corporation, New England, I think I can say without challenge, has the greatest natural pure-water supply in the whole world. We seem endowed with it.

In Boston, today, as you all know, we are most fortunate. We pay for the water we use and no more. Every house in Boston today is equipped with a meter. A minimum charge is set in accordance with the type of building, whether it is a one-family, two-family or twenty-apartment building. Then on top of that you pay so much for each 100 cubic feet used during the year. In this way the waster of water is penalized, and the man who is economical pays a right price for his water. I think that is a wonderful system.

It is a pleasure to be here. The Mayor wished me to be sure and say that he wants you to come to Boston often. Instead of finding, as is sometimes told, a cold and a frost, even in the hot days of summer, Boston is now found to be a warm-hearted place. We want everybody to feel that the citizenry of Boston, from the Mayor to its humblest citizen, wants people to come to Boston and enjoy its hospitality. I thank you for the opportunity of saying "Hello" to you. The Mayor also wanted me to impress the fact upon you that he deeply regretted that he could not be here personally, but he hopes that you have enjoyed your stay with us.

I thank you. (*Applause.*)

The President. We are fortunate tonight in having with us one of Boston's leading citizens: an eminent engineer. Whether he is engaged in building subways or filter plants, great war bases or roads in Cuba, Spain or Japan, or managing one of the largest postal districts in the country, he is always at home on the job, and he leaves with the stamp of his ability and genius upon it.

In addition to being a guest he is a member of this Association; his father was one of the charter members fifty years ago. I take great pleasure in introducing Colonel Charles R. Gow. (*Applause.*)

Colonel Gow addressed the meeting, his subject being "Business Depressions and their Causes."

President Finneran read his address. (See page 388.)

Secretary Gifford announced the election by the Executive Committee of the following new members and associates:

*Commissioner of Penal Institutions.

Members: Patrick Barry, Cambridge, Mass.; Lester A. Bridges, Newburyport, Mass.; Theodore White Grindle, Bar Harbor, Me.; George E. Clapp, West Acton, Mass.; Edmund C. Sanderson, Winchester, Mass.; Alexander Birnie, Reading, Mass.; Birdsell B. McIntyre, Houlton, Me.

Associates: American Active Carbon Corp., Columbus, Ohio; Multi Steel Company, New York, N. Y.; East Jersey Pipe Company, New York, N. Y.; Nelson Cement Stone Co., Inc., Quincy, Mass.

FRIDAY, OCTOBER 2.

Automobiles left the Hotel Statler about 9.00 o'clock in the morning for an excursion over the Metropolitan Water Works System, stops being made at various points. Luncheon was served at the Wayside Inn, Sudbury, after which the party proceeded to the Wachusett Reservoir at Clinton.

(*Adjourned.*)

President's Address.

BY GEORGE H. FINNERAN.

To be president of a society like the New England Water Works Association with its background of fifty years of organized service, directed and promoted by a long line of men strong in character and capable in effort, whose accomplishments form a considerable part of the history of progress in water-works theory and practice, is not only a great honor but also a somewhat sobering circumstance. It causes one to ask oneself, "Am I upholding the traditions of the society; am I carrying on its purpose on the same high plane as my predecessors?"

Fortunately for the present incumbent of the office, those same predecessors built so well and established policy and practice with such wisdom and effect that the organization has not lost the momentum resulting from their efficient and effective guidance and control.

The work of direction, therefore, is not so difficult as it might seem to be. However, general conditions have changed and are continuing to change, and it is necessary to modify somewhat those ways and means held to be sufficient in the past, in order to conform with present and future requirements. We are thereby stimulated in our desire to do constructive work to the end that the Association may render service in accordance with the concepts of the day.

Before making what I consider to be some suggestions, growing out of my work as president, I should like to review, briefly, some of the accomplishments of the past year, as follows:

Good attendance at our winter meetings.

A change from the City Club to Hotel Brunswick which brought to our gatherings more warmth and sociability by reason of facilities for comfortable conversation and contact; the arrangement of the public rooms in the Hotel Brunswick being especially favorable for detachment of the members into small groups before and after the dinner.

A change in the character of the papers read at the meetings, with the purpose and result of developing a more general discussion among the practical men present.

A successful April meeting in New Haven, Conn., thereby bringing the Association to those of its Connecticut membership who find it inconvenient to attend the Boston meetings.

The maintenance of the Journal at its usual high standard.

The publication of an index to our Journal and a membership list.

An increase in the membership.

The meeting of our budget, a respectable balance being left.

An enjoyable outing in June at Sandy Burr Golf Club; this being somewhat of an innovation, giving members and guests an opportunity to play golf on a good course — in addition to the usual features of entertainment.

An amendment to the constitution affecting the election of officers, whereby it will be unnecessary after this year to drop one of the two directors whose terms expire yearly and thus lose an experienced and valuable official. Henceforth, the term of one director only will expire each year. This will make it possible to nominate him for second vice-president and place him in line for further service.

Finally, the adoption by the Executive Committee of the idea of my predecessor, Robert Spurr Weston, to have the Association provide and sponsor a so-called Water Works School. A Committee, consisting of Robert Spurr Weston (Chairman), Percy R. Sanders and Gordon M. Fair, was appointed to meet this desire of the members for more or less formal instruction in the art of water supply, and reported on their conclusions. Said report was accepted at the June meeting of the Executive Committee and this Committee on Educational Service, so-called, was continued with directions to organize the first school at Boston in 1932, with the coöperation of the Harvard Engineering School and the Massachusetts Institute of Technology. It is my hope that the school will be a success.

Every organization, as well as every person, should have an ideal — a vision — a goal to strive for. The Constitution of the NEW ENGLAND WATER WORKS ASSOCIATION states that the object of the Association "Shall be advancement of knowledge relating to water works and water supply and the encouragement of professional and social intercourse among water-works men."

While this has been the guiding spirit of the Association all the years of its life, it is desirable, and sometimes necessary, to provide new ways and means for the realization of those principles, that will comport with the changing conditions of the times. Therefore, I am going to make the following suggestions:

First and foremost, we should make a drive for increased membership. While there has been a slight increase over last year, yet compared with the years 1916 and 1917 we are about 20 per cent. less in members. The organization that is not continually adding new blood may be considered as dying. Nothing stands still in this world. It is moving either forward or backward, up or down, gaining or losing. There is a big field for the cultivation of new members. In Massachusetts alone, I find there are more than 270 communities and water companies that appear to have no representation in our Association. In Connecticut there are 93; in New Hampshire, 65; in Vermont, 62; in Rhode Island, 39; and in Maine, how many I do not know, but it is certain there are quite a number. It is, therefore, apparent that here is an opportunity for a Committee on increased membership to do valuable work.

Last year and for one or two years previously, the Association tried out the idea of holding an extra meeting in some city other than Boston. The two or three that have been held proved to be quite successful. The value of holding meetings at points distant from Boston lies in the oppor-

tunity it presents to distant members to attend our meetings personally, and not through reading the JOURNAL.

It is not always possible for a member located so far from Boston that he will have to stay overnight, to make the trip, especially during the winter months. The interest of those members who do not attend the meetings is likely to lessen, and ultimately they may drop out. A member who does not attend the meetings loses one of the most important benefits of the Association, viz: — personal contacts with the opportunity for a personal exchange of knowledge. We, therefore, should continue these extra meetings and, if possible, hold one of the regular meetings also in some city besides Boston. In other words, if the members cannot come to the meetings, the meetings should go to the members.

The meetings should be made as attractive as possible. The papers read and subjects discussed should be sufficiently diversified to appeal to all. There has been complaint that too many papers are so technical in subject and treatment that they go over the heads of the average members. It should not be lost from sight that the Association is essentially a superintendent's society, organized by practical men, for practical purposes. I think that during the last year some improvement has been made in this matter.

Papers of unusual length with graphs and "dry as dust" statistics should be read in abstract only. Efforts should be made by the writers to translate their messages into simple, everyday English, so far as it is possible. There is frequently the temptation to convey an impression of deep, scientific knowledge by the use of complex phraseology, enigmatic terms and formulæ. Those members who cannot follow the reader into his jungle of words, should be urged and encouraged to stand up after the paper is read and ask the author to elucidate, or in other words, to explain. I think this would have a tendency to make the authors simplify their language.

Writers of papers should be urged to illustrate as much as possible. There is nothing that claims the attention so much, and is so easily comprehended, as a picture.

Readers of papers should try very hard to make themselves heard and understood. Many interesting and valuable papers lose their effect through poor reading. It would seem that after writing the paper the author would be so familiar with it, that he could afford to give a little attention to his delivery. I sometimes think it would be an advantage for an author with poor delivery to have his paper read by somebody who could make it heard and understood by everybody in the room.

Another means of promoting discussion and making our meetings of benefit is to make a special effort to have certain members present when a paper is to be read on a subject with which those members are particularly familiar. If possible they should be given advance copies of the paper and come prepared to discuss the same.

The Association should, through some medium or instrument, keep its members posted on legislation that affects the interests of its members. It is true that we already have a representative who attends hearings in the Massachusetts State House on bills relating to Water Works, but there are legislatures in New England other than that of Massachusetts. Some more general and comprehensive plan should be devised to send out this information. I am sure it would be appreciated in these days of high-powered legislation.

A matter that has occurred to me often during my term as president is the value which a full-time secretary might be to the Association. Our present secretary is a very competent man, and his years of service to the Association have been of great value. Yet he is a busy man. He has other interests that claim a considerable part of his time, and rightly so, as we cannot reasonably ask him for more, in exchange for the small compensation that he receives. His valuable services are practically a labor of love, devoted to the welfare of a society of which he has become a vital part. If any change should be made, ways and means should be found whereby his knowledge, experience and wise counsel, should be available at all times. In other words he should not be separated from the work he now so ably performs.

A full time secretary could, in a short time, lift the Association to a plane of great service. His office could be made a clearing house of water-works information, and a focal point where members could call and meet and keep in touch with current events.

At present, the line of interest and action in the Association seems to fluctuate all through the year. It reaches high points at the meetings and at conventions, and it strikes low points between meetings and conventions; especially so during the summer time.

A full-time secretary could keep the interest sustained all the time through his various activities relating to the affairs and work of the society. Such an official could attend to the advertising in our JOURNAL, keep up a continual membership drive, attend to legislative business, acquire and dispense general water-works information, perhaps be a medium of employment by which help of all kinds could be furnished, attend to the affairs of the new school that we shall have, and so on.

It is true that we have at present the use of the Tremont Temple rooms of the Engineering Societies of Boston, of which we have become a part; but somehow it strikes me that for some reason these quarters are not used by our members as they should be. Whether they feel as if they are not welcome, or whether the atmosphere is a little cold or uninviting, I cannot say. I can say for myself, however, that I always feel when there, as if I am in a church, as if I must whisper and tip-toe for fear of disturbing some reader or research man delving into the depths of some abstruse subject. Business quarters with a more or less social atmosphere cannot be combined with a library.

The financial side of this matter is quite a factor and the proposition should be given serious thought. My purpose in bringing it to your attention is that it may start something that will develop more life, warmth and continuity of activity in the Association, all of which will make it of more real practical value to its members.

There is no other public utility entrusted to municipal officers that compares in point of responsibility with the water system. It is possible for a city to live without gas or electricity or good streets, and for a time without sewers, but if for any reason the water supply is cut off for a very short period, municipal life is ended. Water-works men, therefore, should realize more than they do their importance in present-day life. They should demand fuller recognition of their worth. They should get rid of an inferiority complex and stand up and assert themselves. To try to do this individually sometimes results in failure, but through organization it can be put over.

Let us remember those sturdy characters that built this Association fifty years ago. Let us try to put into our work the same earnestness and determination to overcome obstacles that they did. Let us hold to their lofty ideals and purposes, and, if possible, advance from where they left off.

Remember that in union there is strength, and from a firmly welded and purposeful organization will come a service and power that will make us water-works men useful and valuable to the country in which we live and a vital factor in the progress of present-day life.

That the NEW ENGLAND WATER WORKS ASSOCIATION may thrive and prosper for again fifty years and more is my closing wish. (*Applause.*)

Annual Report of the Secretary.

Mr. President and Gentlemen of the New England Water Works Association: The Secretary submits herewith the following report of the changes in membership during the past fiscal year, and the general condition of the Association.

The present membership is 816, constituted as follows: 13 Honorary, 690 Members, 0 Juniors, 14 Corporate Members and 99 Associates. The detailed changes are as follows:

MEMBERSHIP.

September 1, 1930.	Honorary Members	13			
September 1, 1931.	Honorary Members	13			13
September 1, 1930.	Members, Total		698		
	Withdrawals:				
	Resigned	15			
	Dropped	5			
	Died	9	29	669	
	Elections:				
	September, 1930	6			
	November, 1930	3			
	January, 1931	3			
	February, 1931	1			
	March, 1931	2			
	April, 1931	4			
	June, 1931	2		21	
					690
September 1, 1930.	Juniors, Total		0		
September 1, 1931.	Juniors, Total		0		0
September 1, 1930.	Associates, Total		96		
	Withdrawals:				
	Resigned	7	7		
				89	
	Elections:				
	September, 1930	6			
	January, 1931	1			
	March, 1931	2			
	April, 1931	1		10	99
September 1, 1930.	Corporate Members, Total		15		
	Withdrawals:				
	Resigned	1	1		14
September 1, 1931.	Total Membership				816
September 1, 1930.	Total Membership				822
	Net loss				6

Elections, September 1, 1930 to September 1, 1931.

Members.

September 23 to 26, 1930. Thomas R. Camp, Thomas H. Casey, William B. Duffy, William A. Hardenbergh, Walter S. Hayward, George F. Wieghardt. (6)
November 12, 1930. Kirk Bryan, Edward B. Riley, Edward J. O'Brien. (3)
January 14, 1931. Clarence B. French, Wilfred L. Newman, E. Gardner Penniman. (3)
February 11, 1931. Edward H. Eldredge. (1)
March 11, 1931. Nelson Boardman, Cornelius R. D. Murphy. (2)
April 28, 1931. Frederick E. Babbitt, A. Benjamin Conant, Arthur G. Picher, Dennis P. Sullivan. (4)
June 23, 1931. Michael E. Quirk, Walter A. Sancrie. (2)

Associates.

September 23 to 26, 1930. McEverlast, Inc., Pardee Engineering Company, Joseph G. Pollard Company, Inc., Charles L. Shea, Vogt Brothers Mfg. Co., Wailed Dove-Hermiston Corporation. (6)
January 14, 1931. Hume Pipe of N. E., Inc. (1)
March 11, 1931. Dresser Mfg. Co., Eureka Pipe Company. (2)
April 28, 1931. E. L. LeBaron Foundry Co. (1)

Withdrawals, September 1, 1930 to September 1, 1931.

Members.

Died: Edward W. Bemis, A. A. Gathemann, Allston F. Hart, Silas T. Lawry, George H. Leland, Ernest E. Randall, George F. Swain, Henry A. Symonds, Henry D. Woods. (9)
Resigned: Clark D. Abbott, Philander Betts, Dr. Luther G. Bunker, John H. Damon, Charles F. Eveleth, Milton A. Gilpin, John W. Hartigan, Fred W. King, A. G. Levy, Harold A. Noyes, Thomas A. Pierce, Clifton L. Rice, Robert L. Totten, John H. Walsh, E. C. Willard. (15)
Dropped: Irving C. Bull, Edward Drake, F. E. Driscoll, William L. Howard, Thomas A. Rich. (5)

Associates.

Resigned: Bennett Company, Chicago Pneumatic Tool Company, Walter W. Field and Son, John Fox and Company, W. & L. E. Gurley, National Tube Company, The Smith and Abbott Company. (7)

Corporate Members.

Resigned: Fall River Water Board. (1)

Receipts for Fiscal Year, September 1, 1930, to September 1, 1931.

Entrance Fees			$163.00
Annual Dues:			
Members	$3 868.58		
Corporates	150.00		
Associates	1 860.00	$5 878.58	
Fractional Dues:			
Members	30.00		
Associates	45.00	75.00	
Past Dues:			
Members	69.00		
Associates	20.00	89.00	
1931–1932 Dues:			
Members	$13.00		
Associates	10.00	23.00	
Total Dues			$6 065.58
Advertisements			3 922.00
Subscriptions			487.98
JOURNALS			186.02
Sundries			1 138.70
Total			$11 963.28
There is due the Association:			
Advertisements		$603.00	
Subscriptions		80.00	
Reprints		26.37	
Cuts		19.26	
JOURNALS		10.00	
Indexes		2.25	
Standard Specifications		.75	741.63
Total			$12 704.91

Respectfully submitted,

FRANK J. GIFFORD, *Secretary.*

Annual Report of the Treasurer.

September 1, 1930 to August 31, 1931.

The President and Members of the New England Water Works Association:

I herewith submit my report as treasurer for the year ending August 31, 1931.

Receipts.

September 1, 1930 — Cash on hand			$640.62
Initiation fees	$163.00		
Dues	6 065.58	$6 228.59	
Interest and dividends		782.88	
Journal:			
Advertisements	$3 922.00		
Subscriptions	487.98		
Sale of Journals	186.02		
Sale of reprints	263.05		
Sale of cuts	21.57		
Sale of index	2.50	4 883.12	
Miscellaneous:			
Certificates of membership	$12.00		
Filtration forms	7.20		
Standard specifications	.25		
Meter sheets	4.75		
B. S. C. E. (one-half expense of June Outing)	42.92		
Express	1.58	68.70	
Total receipts			$11 963.28
			$12 603.90

Expenditures.

Journal:			
Advertising agent's salary and commission	$181.40		
Editor's salary	500.00		
Editor's expense	36.12		
Plates	280.49		
Printing	3 208.50		
Reporting	344.45		
Reprints	702.35		
Stationery and postage	90.57		
Index to Journal	783.25		
Sundries	8.20	$6 135.33	
Office:			
Engineering Societies of Boston	$2 160.00		
Exchange	2.69		
Printing, stationery and postage	164.97		
Secretary's salary	400.00		
Secretary's expense	18.91		
Treasurer's salary and bond	112.50		
Sundries	82.73	2 941.80	

Meetings and Committees:			
Badges	$29.00		
Committee on pipe, share of expense	400.00		
Dinner for guests	27.60		
Printing, stationery and postage	420.56		
Stereopticon	65.00		
Sundries	266.84	1 209.00	
Constitution and Membership List		$368.75	
Total expenditures			$10 654.88
August 31, 1931 — Cash on hand			1 949.02
			$12 603.90

Invested Funds.

Invested Funds, September 1, 1930		$15 622.43
Profit on bonds matured	$185.00	
Interest on bonds	80.00	
Interest on deposits	60.52	
Interest on savings bank deposits	642.36	967.88
		$16 590.31
Interest paid over to the Association		$782.88
Invested funds, August 31, 1931		15 807.43
		$16 590.31

The Finance Committee for the fiscal year ending August 31, 1931, recommended a budget of $13 000.00.

There has been expended during the year $10 654.88, leaving an unexpended balance of $2 345.12. The details are as follows:

	Journal.	Office.	Meetings.	Constitution and Membership List.
Appropriation	$8 000.00	$3 100.00	$1 600.00	$300.00
Transferred from	68.75	.....	.....	.....
	$7 931.25	$3 100.00	$1 600.00	$300.00
Transferred to	.....	.....	.....	68.75
	$7 931.25	$3 100.00	$1 600.00	$368.75
Expended	6 135.33	2 941.80	1 209.00	368.75
Balance	$1 795.92	$158.20	$391.00	$000.00

On May 1, 1931, the two bonds of the Lake Shore & Michigan Southern Railroad owned by the Association matured. These had been carried with a book value of $1 815.00; we therefore, received $185.00 which was added to our invested funds.

With the approval of the President, the $2 000.00 was deposited in the Suffolk Savings Bank of Boston.

It was estimated that the new index to the Journal would cost $1 000.00 and that the new list of members would cost $300.00. The actual costs were respectively $783.25 and $368.75.

We have therefore, been able to keep well within the budget appropriation, and carry over a substantial balance to the new year.

Respectfully submitted,

Albert L. Sawyer, *Treasurer.*

TREASURER'S REPORT.

STATEMENT OF RECEIPTS AND EXPENDITURES.

Receipts.	
Cash on hand September 1, 1930	$640.62
Interest on bonds and deposits	782.88
Received from Secretary	11 180.40
	$12 603.90

Expenditures.	
Bills paid as per vouchers	$10 654.88
Cash on hand August 31, 1931	1 949.02
	$12 603.90

ASSETS AND LIABILITIES.

Assets.		
Cash in banks as per list		$17 756.45
First National Bank	$1 949.02	
City Five Cents Savings Bank	2 000.00	
Farmers and Mechanics Savings Bank	2 068.46	
Franklin Savings Bank	2 000.00	
Haverhill Savings Bank	2 000.00	
Home Savings Bank	1 011.25	
Mechanics Savings Bank	1 261.19	
Pentucket Savings Bank	2 000.00	
Peoples Savings Bank	1 466.53	
Suffolk Savings Bank	2 000.00	
Accounts Receivable		741.63
Advertisements	603.00	
JOURNALS	10.00	
Subscriptions	80.00	
Reprints	26.37	
Cuts	19.26	
Indexes	2.25	
Standard Specifications	0.75	
		$18 498.08

Liabilities.	
Surplus	$18 498.08
	$18 498.08

Annual Report of the Editor.

To the New England Water Works Association: The Editor submits herewith the following report for the year ending August 31, 1931.

As has been customary in the past, the tables of financial figures, accompanying the report, are based upon total charges and accounts receivable, rather than actual cash received or disbursed.

Table 1 is a statement of the material published.

Table 2 gives the receipts and expenditures for the year.

Table 3 is a comparison of the Journal for the past year with preceding years.

Size. The four issues contained 682 pages, of which 410 were text.

Cost. The gross cost of the Journal was $6 135.33, equivalent to $7.52 per member, and the net cost was $1 252.21, equivalent to $1.53 per member.

Reprints. Fifty reprints of each paper have been furnished to the author where desired.

Circulation. The present circulation of the Journal is:

Members, all grades	816
Subscribers	129
Exchanges	10
Total	955

Comprehensive Index. A comprehensive index to the Transactions and Journal of the Association, 1882 to 1930, was issued as Part 2 of the March, 1931 Journal.

(Journals *have been sent to all subscribers.*)

Respectfully submitted,
Gordon M. Fair, *Editor.*

EDITOR'S REPORT.

TABLE 1.

Statement of Material in September and December, 1930, and March and June, 1931, Issues of the Journal of the New England Water Works Association.

Date.	Pages of.								
	Papers.	Proceedings.	Total Text.	Index.	Advertisements.	Cover and Contents.	Insert Plates.	Total.	Total Cuts.
September, 1930	107	2	109	0	47	5	0	161	39
December, 1930	62	40	102	5	47	5	0	159	15
March, 1931 (Part 1.)	86	3	89	0	47	5	0	141	7
March, 1931 (Part 2.)*	0	0	0	45	10	4	0	59	0
June, 1931	108	2	110	0	47	5	0	162	33
Total	363	47	410	50	198	24	0	682	94

*Index to Transactions and Journal, 1882 to 1930.

TABLE 2.

RECEIPTS AND EXPENDITURES ON ACCOUNT OF SEPTEMBER AND DECEMBER, 1930, AND MARCH AND JUNE, 1931, ISSUES OF THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

Receipts.		*Expenditures.*	
Advertisements	$3 922.00	Advertising Agent's salary and commission	$181.40
Sale of JOURNALS	186.02	Editor's salary	500.00
Sale of reprints	263.05	Editor's expense	36.12
Subscriptions	487.98	Plates	280.49
Sale of cuts	21.57	Printing	3 208.50
Sale of Index	2.50	Reporting	344.45
	$4 883.12	Reprints	702.35
		Stationery and postage	90.57
		Sundries	8.20
Net cost of JOURNAL	1 252.21	Index to JOURNAL	783.25
	$6 135.33		$6 135.33

EDITOR'S REPORT.

TABLE 3.

COMPARISON OF JOURNALS OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

	Vol. XXXV. 1921.	Vol. XXXVI. 1922.	Fiscal Year Ending Aug. 31, 1924. 4 issues.	Fiscal Year Ending Aug. 31, 1925. 4 issues.	Fiscal Year Ending Aug. 31, 1926. 4 issues.	Fiscal Year Ending Aug. 31, 1927. 4 issues.	Fiscal Year Ending Aug. 31, 1928. 4 issues.	Fiscal Year Ending Aug. 31, 1929. 4 issues.	Fiscal Year Ending Aug. 31, 1930. 4 issues.	Fiscal Year Ending Aug. 31, 1931.* 4 issues.
Average edition (copies printed)	1 150	1 100	1 100	1 100	1 100	1 100	1 138	1 200	1 350	1 260
Average membership	864	826	764	755	775	784	808	831	822	816
Circulation at end of year	929	929	880	873	906	916	955	993	980	955
Pages of text	399	618	404	421	523	492	528	507	570	410
Pages of text per 1 000 members	462	748	529	558	675	628	654	610	693	502
Total pages, all kinds	560	801	611	644	761	724	769	745	812	682
Total pages per 1 000 members	648	970	800	853	982	952	952	896	988	836
GROSS COST:										
Total	$5 381.84	$6 354.10	$4 783.60	$5 272.91	$6 524.62	$5 839.36	$6 849.44	$6 740.87	$8 054.59	$6 135.33
Per page	9.61	7.93	7.83	8.19	8.57	8.07	8.91	9.06	9.92	9.00
Per member	6.23	7.69	6.26	6.98	8.42	7.45	8.48	8.12	9.80	7.52
Per member per 1 000 pages	11.12	9.60	10.25	10.84	11.07	10.29	11.02	9.77	12.07	9.00
Per member per 1 000 pages text	15.61	12.47	15.50	16.58	16.10	15.13	16.06	16.01	17.19	18.34
NET COST:										
Total	$1 869.85	$2 434.26	$561.51	$943.40	$2 040.28	$710.63	$1 716.25	$1 857.58	$3 664.76	$1 252.21
Per page	3.34	3.04	0.92	1.46	2.68	.98	2.23	2.07	4.51	1.84
Per member	2.16	2.95	0.74	1.25	2.64	.91	2.12	2.24	4.46	1.53
Per member per 1 000 pages	3.87	3.68	1.20	1.94	3.47	1.26	2.76	2.50	5.49	2.24
Per member per 1 000 pages text	5.43	4.77	1.82	2.97	5.05	1.85	4.02	4.41	7.82	3.73

*Including Comprehensive Index, 1882 to 1930.

REPORT OF FINANCE COMMITTEE.

To the Executive Committee of the
New England Water Works Association.
Gentlemen:

The Finance Committee has examined the books and accounts of the Secretary and the Treasurer for the fiscal year ending August 31, 1931 and finds them correct.

The Committee submits the following budget for the fiscal year ending August 31, 1932:

	Expended. 1930–1931.	Recommended. 1931–1932.
JOURNAL	$6 135.33	$7 000.00
Office	2 941.80	3 200.00
Meetings and committees	1 209.00	1 600.00
Publication of Constitution, By-Laws and List of Members	368.75	.....
	$10 654.88	$11 800.00

The amount recommended for expenditure the coming year is $11 800.00. This is $1 200.00 less than last year's recommendation which was made larger than usual on account of the unusual expenditures of printing the Index and List of Members.

The receipts for the year ending September 1, 1931, were $11 963.20. The receipts for the fiscal year ending September 1, 1932, are estimated to be about $11 400. This is $400. less than the budget recommended but there is a cash balance of $1 949.02 which allows plenty of leeway without drawing on invested funds.

The budget might possibly have been cut a little more. However, the Finance Committee feels it would be better to have ample funds so that each department could keep within its appropriation.

Respectfully submitted,
HENRY T. GIDLEY,
A. H. O'BRIEN,
D. W. FOSTER,
Finance Committee.

August 27, 1931.

Report of the Committee on Educational Service.

April 30, 1931.

To Mr. George H. Finneran, President.

Pursuant to your instructions, your Committee on Educational Service met in Boston yesterday, and after a thorough discussion, agreed on the following report.

Your Committee was appointed to meet a definite desire among members of the Association and others for more or less formal instruction in the art of water supply.

This desire is not a new one. In former years when the Association was smaller and the art of water supply less highly developed along scientific lines, the desire was largely satisfied at the meetings and conventions of this Association, but with the growth of the Association and the elaboration of the art of water supply there has arisen an insistent demand for short courses of instruction in the principles of water supply.

So-called water works schools have been established at various universities in the west, either under the auspices of a local Water Works Association or of a State Department of Health. These schools resemble one of our conventions in character, with the exception that the papers are generally more elementary. To follow this method in New England, which probably would mean a lessening of interest in the papers and a deterioration in the quality of our Journal, does not seem wise.

Some have suggested a school in which practical water works arts, like pipe laying, meter repairing, etc., would be taught, but it seems to your Committee that it is more important to instruct water works employees in the WHY rather than the HOW of water supply. It is believed that a water works employee will be more benefited by a general survey and a general understanding of principles of water supply than by further instruction in the field of his daily occupation.

With the above reasoning in mind, your Committee has reached the following conclusions, and makes the following recommendations:

(1) The establishment of a short water works school is entirely feasible and advisable.

(2) The period of instruction should be one week.

(3) The course should consist of classes, laboratory work, excursions and lectures. Generally speaking, classes should be held in the morning, laboratory work or excursions should be conducted in the afternoon, and lectures should be given on some of the evenings, leaving one or more evenings for rest and recreation.

(4) The school should be sponsored by the Association and the State Departments of Health in New England.

(5) The school should be conducted by coöperation with leading New England educational institutions — two of which, the Harvard Engineering School and the Massachusetts Institute of Technology,—

have already promised through their professors of sanitary engineering to assist in conducting such a school.

(6) It is recommended that the first school be held in Boston during the last of January or the first of February when educational facilities are available because of the mid-year examination period, and provided twenty men will join the school.

(7) It is estimated that a fee of $15.00 for each student will cover the cost of instruction, but not, of course, of travel and subsistence.

(8) It is suggested that water companies, water departments or water commissions pay the fees of their employees who may attend.

(9) It is suggested that as a general rule no one but water works employees be admitted to the course.

(10) In order to be assured of the character of the attending students, it is recommended that no one, not a member, be admitted unless he be recommended by a member of the Association or following the application of a water company or a water commission or department.

(11) A certificate to be given each one completing the course satisfactorily.

(12) The Association to be responsible for enrollment and for the collection of fees; also, for all announcements, printing of programs, and the publishing of those papers and addresses given during the course which are suitable for the JOURNAL of the Association.

(13) While Boston is the logical place for the first session of the school, it would probably be wise in future years to hold a school at Providence, New Haven, or other places where schools with facilities for instruction exist and where informative excursions and demonstrations may be arranged.

(14) It is recommended that if the Executive Committee approves of the plan, it continue the committee to organize the first school at Boston in 1932 with the coöperation of the Harvard Engineering School and the Massachusetts Institute of Technology.

Trusting that the above will meet with the approval of the Committee, we remain

Yours respectfully,

ROBERT SPURR WESTON,
PERCY R. SANDERS,
GORDON M. FAIR,
Committee on Educational Service.

NOVEMBER MEETING.

HOTEL BRUNSWICK, BOSTON, MASS.

Wednesday, November 18, 1931.

President George C. Brehm in the Chair.

Secretary Gifford announced the election by the Executive Committee of the following members and associates:

Members: Irving B. Crosby, Consulting Geologist, Boston, Mass.; Daniel J. Donovan, Assistant Civil Engineer, Metropolitan District Commission, Water Division, Boston, Mass.; Linn Harrison Enslow, Editor "Water Works and Sewerage," New York, N. Y.; Samuel F. Newkirk, Jr., Engineer and Superintendent, Board of Water Commissioners, Elizabeth, N. J.; Chester L. Nyman, South Essex Sewerage District, Salem, Mass.; Kenneth E. Packard, Clerk, Auburn Water District, Auburn, Me.; Everett E. Turkington, Electrical Engineer with Associated Factory Mutual Fire Insurance Companies, Boston, Mass.; Angelo Alfonse Potenza, Superintendent Medway Water Department, Medway, Mass.

Associate: Jenkins Bros. (Reinstated.)

Arthur D. Weston, Chief Engineer, Massachusetts Department of Public Health, Boston, Mass., read a paper "Effect of Present Economic Conditions upon Water Supplies."

C. Edward Behre, Director, Northeastern Forest Experiment Station, U. S. Department of Agriculture, Amherst, Mass., read a paper "Are Further Studies Needed on the Relation of Forests to Water Supply in New England?"

Harold O. Cook, Massachusetts State Forester, Caleb M. Saville, Manager and Chief Engineer, Water Bureau, Metropolitan District Commission, Hartford, Conn.; Harris A. Reynolds, Secretary, Massachusetts Forestry Association, Boston, Mass.; Charles E. Kendall, Water Commissioner, Winchester, Mass., and C. R. Tillotson, District Inspector, U. S. Forest Service, entered into the discussion.

Mr. Guy W. Classon and Mr. E. Sherman Chase showed moving pictures taken at several of last year's meetings and during the last convention.

(*Adjourned.*)

HENRY ALLEN SYMONDS.

Henry Allen Symonds, son of William F. and Abbie M. (Washburn) Symonds was born in Hancock, N. H., on September 23, 1871 and died in Boston on February 17, 1931.

After attending the schools of his native town and the University of New Hampshire and Tufts College, he entered the Thayer School of Engineering at Dartmouth College, receiving the degree of C.E. in 1894.

In 1895, as resident engineer for E. Worthington on the construction of the Billerica water system, Mr. Symonds began his career as a water-supply engineer and continued in that line of work up to the moment of his death, which occurred while in conference at the office of a client in Boston.

As resident engineer for Mr. Worthington and Mr. Percy M. Blake and as a member of the firm of Booth & Co., contractors, he obtained an intimate knowledge of water-works construction, which, with the operating experience gained while acting from 1905 to 1907 as Superintendent of Water Works at Athol, Mass., formed a broad and practical foundation for his later activities as a consulting engineer.

During this last phase of his career, as a member of the engineering firm of Blake & Symonds, as consulting engineer for the Hanscom Construction Co., and as a private consultant and member of the firm of Symonds & Stevens, Mr. Symonds was active in the study, promotion, design and construction of municipal water systems, and leaves as monuments to his engineering ability and untiring persistency, successful plants in many New England towns.

A member of this Association for over twenty years and taking an active part and interest in its papers and discussions, he was Editor of the JOURNAL from 1917 to 1922. Mr. Symonds was also a member of the American Society of Civil Engineers, the American Water Works Association, Boston Society of Civil Engineers and Thayer Society of Civil Engineers.

Besides his widow, Eliza P. (Tuttle) Symonds, Mr. Symonds is survived by a daughter Marion E. Symonds and three sons, Allen M. Symonds, manager of the Milbury and Grafton water companies, Edmund and Robert Symonds.

A man of uncompromising integrity, whose word was law and scripture to his clients and associates, Henry Symonds will probably be best remembered for his professional ideals, his kindly manner, his unfailing courtesy and his persevering loyalty to his friends.

FRED O. STEVENS.

FRANK HERBERT TORREY.

Frank Herbert Torrey was born in North Weymouth on January 24, 1854, the son of Alexis and Lucena (Yeaton) Torrey, and died at North Weymouth on July 3, 1931.

Although a member of this Association for but a short time, Mr. Torrey was prominent in the water-supply affairs of Weymouth for nearly fifty (50) years.

A member in 1883 of the original committee to report on a system of water works for the Town of Weymouth, he served for twenty-nine years on the Board of Water Commissioners, eighteen years as Chairman.

Mr. Torrey greatly enjoyed the meetings of this Association, especially the resulting social contacts, and often expressed the wish that he might have been a member throughout the years of his service as a water commissioner.

FRED O. STEVENS.

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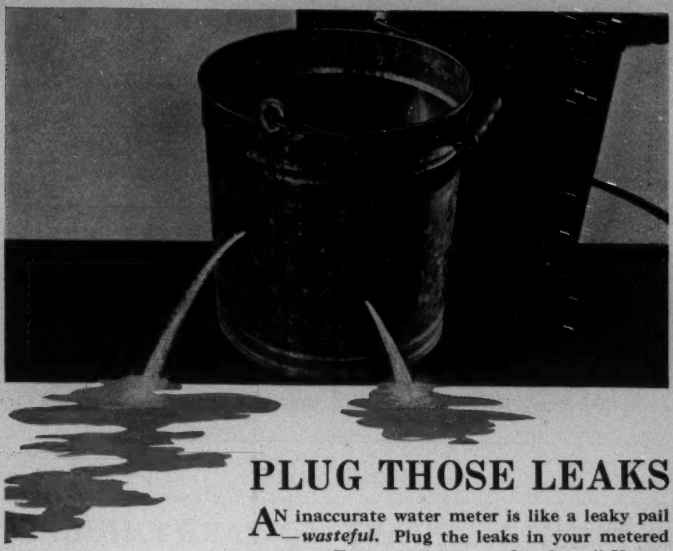

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For *accurate* meters that will return just revenue, write the nearest Hersey Branch Office. An engineer there will gladly specify for you.

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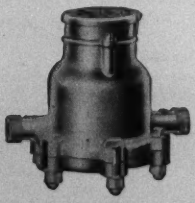

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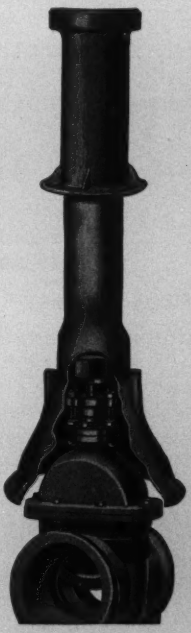

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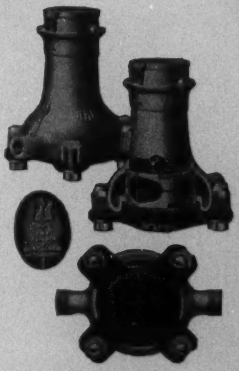

Note: Above drawing does not show projecting "sand-ring"— now a standard part of the Disc Chamber.

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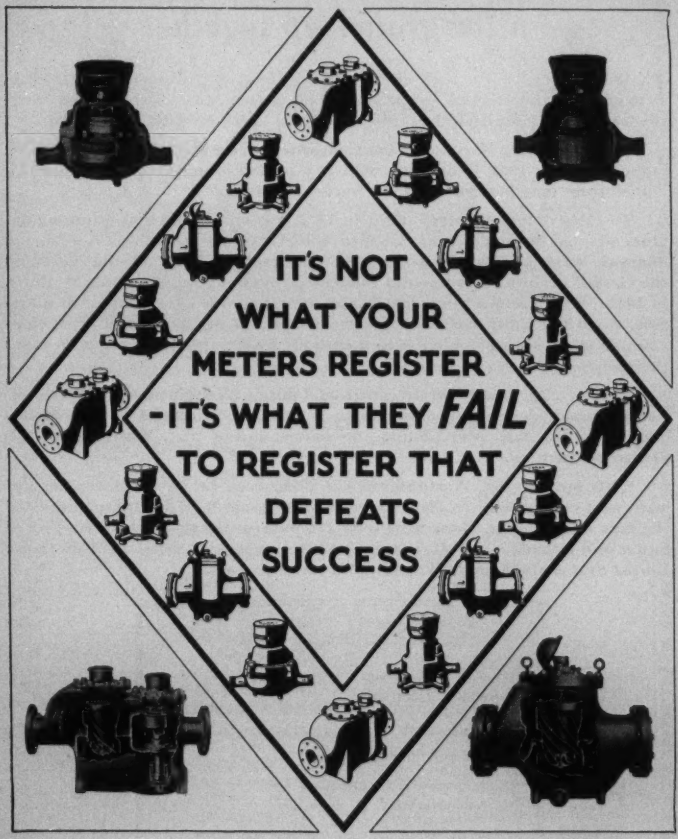

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Waterworks and Worthington
have grown up together

IN 1845, Henry R. Worthington opened a little shop in Brooklyn, New York, to manufacture his new steam pump. Since then, the history of Worthington has closely paralleled the story of progress in waterworks engineering.

When the Holly Manufacturing Company became part of the Worthington organization in 1903, it brought with it a wealth of experience and prestige gained from long leadership in the waterworks field.

The Holly "Quadruplex," built in 1872, was one of the first pumping engines adapted to the different pressure requirements of a combination fire and domestic water service. Its popularity was supplanted only by the success of the Gaskill horizontal compound condensing type engine, also built by Holly, in 1882. With certain refinements, this type remained supreme until about 1906, when the Holly vertical triple expansion and the horizontal cross compound engine, both of which were then built by Worthington, began to make themselves felt.

Now . . . the motor-driven centrifugal pump, as engineered by Worthington, typifies modern waterworks practice. Crank-and-flywheel pumps, direct-acting pumps, deep well pumps and power pumps . . . Worthington has pioneered them all.

With meters, too, Worthington has progressed far in the acceptance of waterworks engineers. In 1860, five years after Henry R. Worthington invented the first water meter, there were only 144 waterworks systems in the United States and Canada. In 1931, there are 4839 incorporated municipalities in the United States alone using Worthington water meters.

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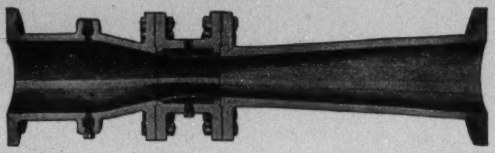

The Venturi Tube

In 1891 the Venturi Tube was new. Those Engineers who knew of it hoped it would help solve the difficult problem of measuring the flow of water in large pipe lines.

In 1931 the Venturi Tube is accepted by Engineers as the most dependable and accurate means of measuring flow through pipe lines.

It may be worthwhile, however, to summarize a few of the important advantages of the Venturi Tube:

1. The flow is guided at all points.
2. The inlet and throat pressures are taken off at definitely fixed points; the annular pressure chambers assure the use of true average pressures.
3. The Venturi throat is accurately centered in relation to the rest of the pipe line.
4. The friction loss through a Venturi Tube is the lowest of any differential producer. The Venturi Meter, then, operates on a greater differential with less friction loss, and is a more powerful instrument with a wider measuring range than other meters.
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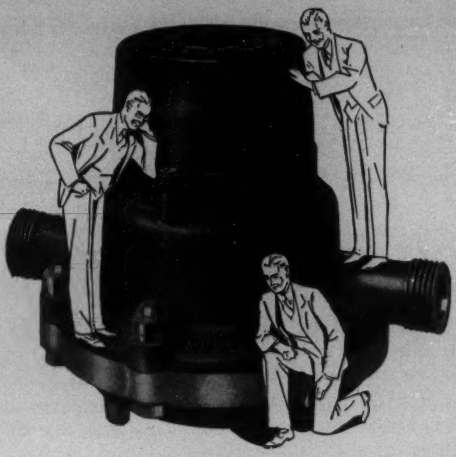

LISTEN!

Should your auto speedometer start to run noisily, you would hurry to repair the defect, for noise in such a precision machine indicates high friction and wear that must be corrected.

Noise in a precision instrument like a water meter should not be tolerated, either. It is annoying to users of the water, and is frequently accompanied by loss of accuracy in the meter.

The noiseless, reinforced measuring disc of American and Niagara Meters. Its extra thickness insures extra accuracy.

But listen to a Niagara or American Meter! Quietly, smoothly these noiseless meters record the gallons with the effortless ease and precision accuracy that you associate with the finest machinery. All their lifetime they stay quiet. These are true precision instruments—none finer of their kind—yet so extra-simple that the cost is kept at a proper figure.

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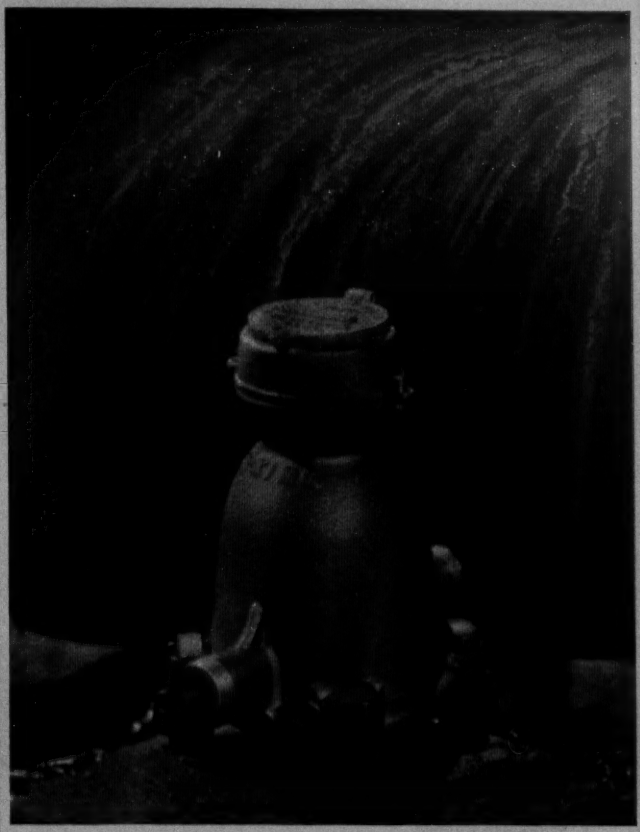

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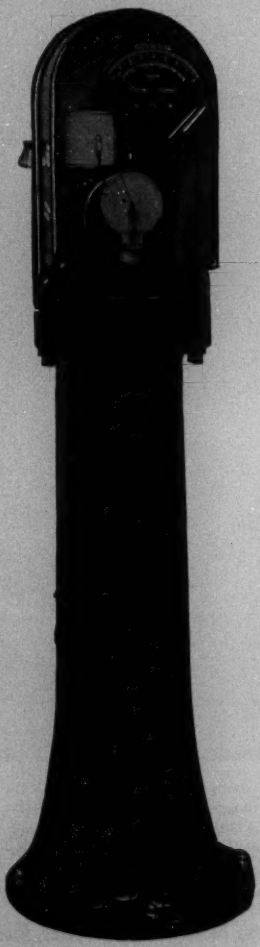

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Record the flow on a rectangular chart with uniform graduations.

Totalize the flow on a five-dial totalizer, so designed that the last figure can be read with accuracy on a much larger scale.

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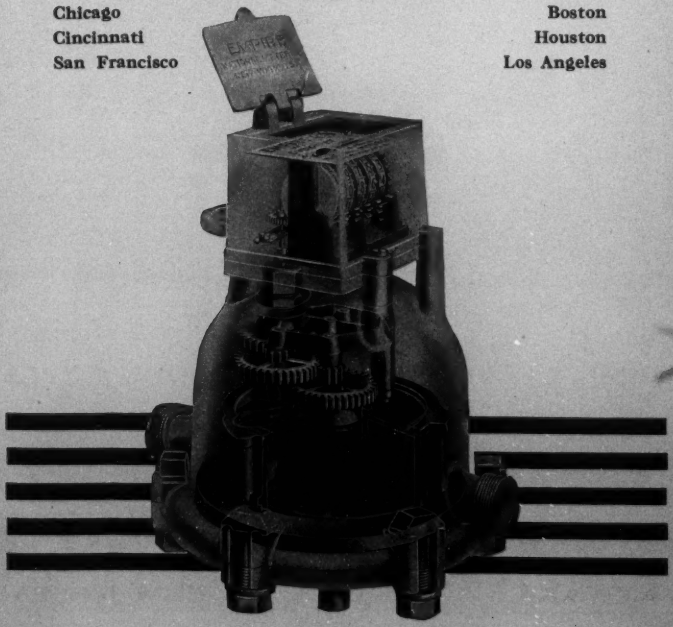
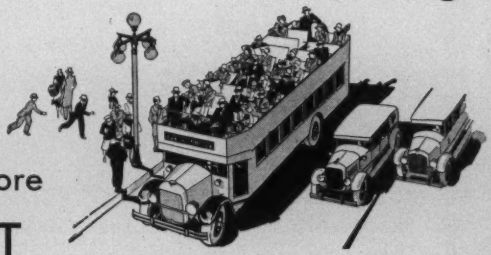


CAPACITY COUNTS



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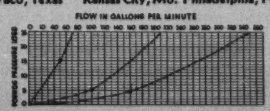
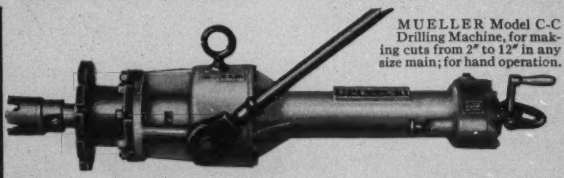


● *Indicates minimum capacity at which a 25 pound pressure loss is allowed by A.W.W.A. Standard.*

BADGER Water METERS

This New MUELLER
DRILLING MACHINE



MUELLER Model C-C Drilling Machine, for making cuts from 2" to 12" in any size main; for hand operation.

presents

10 Signal Improvements!

1. **Increased capacity.** This machine is capable of making a 12" cut in a 12" main.
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8. **Case filled with lubricant** which automatically lubricates every working part every time machine is used.
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10. **Boring bar free from indentations;** this eliminates the cutting away of the packing.

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The New MUELLER Model C-C Drilling Machine is the result. It combines features found in no other machine. It presents ten signal improvements, plus MUELLER quality which has been recognized as standard for three-quarters of a century!

MUELLER C-C Drilling Machines are furnished with 2, 3, 4, 6, 8, 10 and 12-inch equipment. Customer may specify the equipment he desires. Machines can also be furnished with 36 inch travel and with cutters ½ inch less than regular for gas companies desiring to drill through welded nipples and valves.

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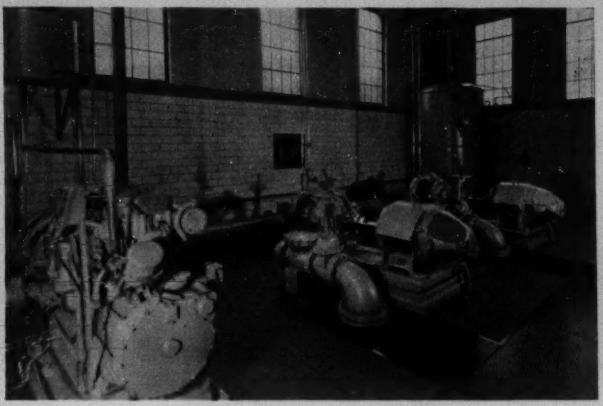

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MINERALEAD

A PROVEN JOINTING MATERIAL FOR WATER MAINS

ABSOLUTE UNIFORMITY

Easy Melting
Rapid Pouring
No Caulking
Tighter Joints
No Radial Cracks

Is checked systematically to insure perfect performance.

Write for Catalogue

Control No. AA1

This Certifies, that the MINERALEAD contained in this carton has been tested for physical properties, chemical constituents, as well as jointing efficiency.

Physical Properties OK Poured Joints OK
Chemical Analysis OK Approved by AMR

THE ATLAS MINERAL PRODUCTS COMPANY
of Pennsylvania
MERTZTOWN, PENNSYLVANIA
ESTABLISHED 1898

New England Distributor
FRED A. HOUDLETTE & SON, INC.
40 Central Street
Boston, Mass.

CLEAN PIPE LINES

having high coefficients deliver more water and give better fire protection than corroded mains.

High coefficients mean greater delivery in gravity mains and lower power costs in pumping mains.

GENERAL PIPE CLEANING COMPANY

Commercial Trust Bldg. Philadelphia, Pa.

The SMITH-HACKENSACK Finest Tapping Sleeve Made.

EXTRA long, extra heavy throughout. Joints at the ends only, thus reducing the quantity of lead necessary to a minimum. Adaptable to more than one class of pipe. Suitable for pressure ranges from 90 to 250 pounds.

The Hackensack Tapping Sleeve may also be obtained with two opposite branch openings for making double or "cross" connections, the cuts in the main being opposite each other.

SMITH
WATER WORKS SPECIALTIES & SUPPLIES

THE A.P. SMITH MFG. CO. *East Orange, N.J.*

Announcing

The New

COPPERHORN!

METER COUPLING SIMPLIFIES BASEMENT METER SETTINGS . . . !

SAVES meter couplings, pipe fittings, pipe joints and labor in installing. *Cuts pipe friction or pressure loss to less than half* that through the ordinary fittings it replaces. *All copper water way.* Pipes are connected and in alignment at all times, whether meter is in or out. Can be used on old or new services. *Write for prices.*

Ford Meter Box Co.
Wabash, Indiana

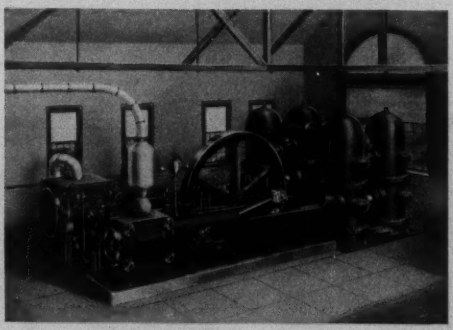
Water Meter Setting and Testing Equipment

MURRAY IRON WORKS CO.

(INCORPORATED 1870)

BURLINGTON, IOWA, U. S. A.

Builders of High Duty Pumping Engines

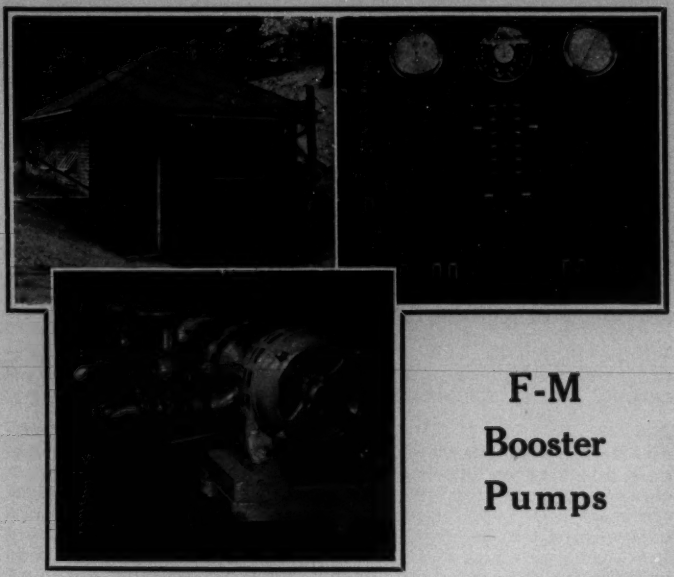


Murray High Duty Crank and Fly Wheel Pumping Engine, Opposed Type

STARKWEATHER & BROADHURST, INC.,
79 MILK STREET, BOSTON

will be glad to show you the superior design and excellent workmanship of the new 3 M. G. D. Murray Pump in the Arlington Pumping Station of the Metropolitan District Commission. Exceptional operating results are being obtained as shown by the official duty test which exceeded the guaranty by a substantial amount.

PLEASE SEND US YOUR SPECIFICATIONS AND CALLS FOR BIDS



F-M
Booster
Pumps

At SOUTH HADLEY, MASS.

Shown above are the exterior of the South Hadley Water Works Pumping Station, the two F-M Motor Driven Centrifugal Pumps installed in the station and the control equipment. The station is located at one extreme end of the town and takes water from a small reservoir under a positive head of approximately 12 or 15 feet and pumps it through the main section of the town to a standpipe at the other end. Both pumps and motors are of ball bearing design, which construction was selected because of the desirable feature of lubrication. The bearings require attention only once a year.

FAIRBANKS, MORSE & CO.

88 High Street, Boston

FAIRBANKS-MORSE

PUMPS · DIESEL ENGINES · MOTORS

HOW Will Your Next Pump Be Driven?

MANY NEW ENGLAND CITIES AND TOWNS are now considering extensions or replacements of their Water Works Pumping Equipment and the first question before the Water Board is always "What is the most efficient, satisfactory, and reliable type of unit, and how shall it be driven?"

AT THIS TIME we are referring only to Centrifugal Pumps as there is little or no demand today for plunger pumps, in view of the extremely high efficiency now developed and the many other advantages of centrifugal water works pumping equipment.

WE SUPPLY, DELIVER, INSTALL, pipe, and turn over in running order, complete pumping plants, whether driven by steam turbine, electric motor, or internal combustion engine.

ALL OF THESE METHODS of driving have their proper well-established place, but we suggest that Water Works Superintendents give very serious consideration to a steam turbine driven centrifugal pump for their next unit. Developments of the last ten years in De Laval steam turbines, reduction gears and pumps have resulted in securing much higher efficiencies, permitting guarantees equal to and in some cases higher than the records held by what have always been termed "high duty pumping units."

WHERE BOILERS ARE already in existence, or even where a new boiler, or boilers have to be purchased, the modern turbo water works pump either direct connected or geared, is unequalled on capitalized operating cost per million gallons pumped. The units are small in size, practically noiseless in operation, have a very low upkeep and maintenance charge, and are extremely reliable. High steam pressure, and super-heat are not essential.

ALL TURBINE DRIVEN water works units are now furnished with automatic self-priming and condensing equipment, and integral injection water pump. Furthermore, all such units are completely tested under operating conditions of steam, water pressure and vacuum before leaving our De Laval works at Trenton, N. J.

We will gladly submit comparable data on steam, electric, Diesel, or gasoline units upon request.

TURBINE EQUIPMENT COMPANY

OF NEW ENGLAND

80 Federal Street Phone LIB erty 5993-4 Boston, Mass.

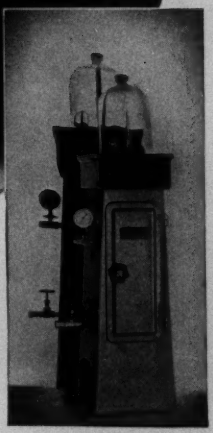
New England Representatives for
DE LAVAL STEAM TURBINE CO., TRENTON, N. J.

CONTROL-

Centralized Traffic Control on a section of Southern Pacific R. R. (Photo: courtesy Union Switch & Signal Co.)

indispensable to CHLORINATION

In chlorination, as in transportation, the safety of human life depends on adequate control. The severest demands of continuous chlorinator service are met with W & T Vacuum chlorinators. More than 3000 installations attest this fact.



A prominent Engineer has this to say—

"..all that I can say relative to the Vacuum type MSV chlorinator is that we have found it to be the safest, surest chlorinator device —giving satisfactory and continuous service. We have had little repair or upkeep expense."

Technical Publication No. 38 describes this chlorinator in detail. Send for it.

"The Only Safe Water is a Sterilized Water."

WALLACE & TIERNAN CO. INC.

Manufacturers of Chlorine Control Apparatus

NEWARK NEW JERSEY

Branches In Principal Cities

SA-30

ATTENTION
WATER WORKS
OF NEW ENGLAND

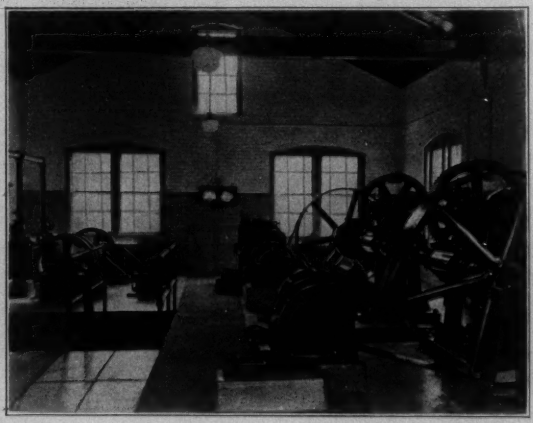
A few reasons why we solicit your inquiries on Water-Works Pumping Equipment:

First. — We make a specialty of furnishing Complete Water-Works Pumping Units of all types.

Second. — Total responsibility of installation is assumed by us.

Third. — We relieve the purchaser of every detail and turn the complete unit over to him under actual operation and with guarantee.

Fourth. — Every unit installed to date has exceeded its guarantee and has been completely accepted.



Remodeled Pumping Station at Bridgewater, Mass., completely installed by F. A. Mazzur Co., Inc. Barbour & Dixon, Eng'r's.

F. A. Mazzur Co., Inc.
141 MILK STREET, BOSTON

Main's Hotcoating for the inside of standpipes and water tanks, will stop all pitting and corroding, and is guaranteed for seven years.

Also

Main's Coverall Salt Air Paint, for the outside of standpipes and water tanks, guaranteed for four years.

M. B. MAIN **Box 189, Somers Point, N. J.**

The "COREY" Hydrant

Why you should use GENUINE COREY HYDRANTS

Water to Nozzles quicker than other Hydrants.

Standpipe can be removed and replaced without shutting off water in main.

Ease of operation insured by knuckle joint principle.

Only 13 turns to completely open or completely close, but full flow with only 4 turns.

Nozzles screwed in — not leaded.

Can be lengthened without shutting off water.

Will not flood if broken.

Positive Drip — cannot freeze.

Standpipe can be revolved quarter turns — Nozzles always in right direction.

Write for copy of our new Catalog "G."

CHARLES L. BROWN,

New England Sales Manager, Lock Box 2, Northboro, Mass.

RENSSELAER VALVE COMPANY

TROY, N. Y.

New England Water Works Association

Specifications and Meter Rate Sheets

Standard Specifications for Cast-iron Pipe and Special Castings, per copy, $0.25

Meter Rate Sheets: Single sheet 0.05

100 sheets, in orange 2.50

100 sheets, in black 2.25

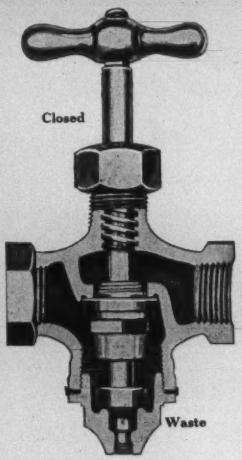
HIGHEST AWARD, GOLD MEDAL,
ST. LOUIS EXPOSITION, 1904

Over 100 Water Departments
use
LEAD-LINED IRON and TIN-LINED PIPES
for their service connections

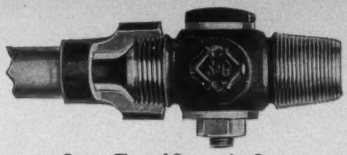
MANUFACTURED BY

Lead Lined Iron Pipe Company

Wakefield ═══ Mass.



Gorham Compression Stop and Waste Cock



Copper Flanged Corporation Stop

S. & G. Water Works Brass Goods

S & D Heavy Pattern Slip Type Service Boxes

Byers' Wrought Iron Pipe

Annaconda Brass Pipe and Copper Service Tubing

Service, Roadway and Valve Boxes

Cast Iron Pipe and Fittings

SUMNER & DUNBAR

12-18 Pittsburgh St., Boston, Mass.

Telephone, LIBerty 1350

PIERCE-PERRY CO.

SUCCESSORS TO

GEORGE E. GILCHRIST CO.

WHOLESALERS OF

Steel, Wrought Iron, Brass Pipe and Water Works Materials of all kinds including copper service pipe and fittings.

236 Congress St., Boston, Mass.

CEMENT LINED SERVICE PIPE

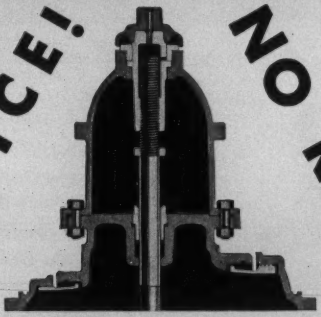
With Specially Adapted Lead-lined Fittings

Also Curb Cocks which eliminate Iron to Brass Corrosion both inside and out.

CEMENT LINED PIPE CO.

LYNN, MASS.

NO ICE! NO RUST!



THE OPERATING THREAD OF THE MATHEWS MOEDRNIZED HYDRANT IS SEALED AGAINST MOISTURE

Ice and Rust are vicious enemies of the Fire Hydrant—cause delays to the Fire Department when delays are disastrous. Just think of the supreme satisfaction in knowing that every hydrant is reliably ready for instant operation—*never disabled by ice or rust.* That's the assurance that MATHEWS HYDRANTS give year in and year out in any climate.

No moisture can reach the Operating Thread because it is protected from the outside by the Shield Operating Nut and from the inside by the Stuffing Box. Therefore no ice or rust can form at this vital spot to interfere with easy, quick opening and closing.

Give your Fire Fighters these advantages. Install MATHEWS HYDRANTS, *and be surer of reliable service.*

R. D. WOOD & CO., PHILA., PA.

ESTABLISHED IN 1803

CAST IRON PIPE—SAND SPUN (CENTRIFUGALLY CAST)
REG. U. S. PAT. OFF.
AND PIT CAST—GATE VALVES—VALVE BOXES

6-inch or 60-inch

—each Kennedy Valve size and type is efficient, dependable, long-lived

THE large Kennedy Valve line includes practically every standard type and size for water works, sewage pumping and fire protection service — all with one outstanding characteristic. This prime characteristic of every Kennedy Valve is its thorough suitability for the service on which it is to be used. When you buy a valve recommended by our long-experienced engineering department, you can be sure that it is designed with an ample margin of strength for pressure and service strains, that it is carefully and accurately built for easy and dependable operation, and that it is made of high grade materials which will stand up for many a year.

Water works superintendents and fire chiefs who have seen Kennedy Valves in action, testify to their thoroughgoing merit. You are safe when you standardize on Kennedy for valves and fire hydrants.

THE KENNEDY VALVE MFG. CO.
Elmira, N. Y.

Branches in principal cities

KENNEDY

VALVES-PIPE FITTINGS-FIRE HYDRANTS

THE STANDARD FOR 50 YEARS

Automatic Pressure Control Valves
Feed Water Filters
Portable Fire Hydrants
Hydraulic Engines
Hydraulic Engines—Booster Pumps

ROSS VALVE MFG. CO., INC. TROY, N. Y.

Health and Protection First

Water delivered through dirty pipes may be a MENACE.

Incrusted water pipes mean inefficiency and loss of Fire Protection.

We Guarantee the Results of Our Method of Cleaning.

WRITE US.

National Water Main Cleaning Co.

50 Church Street New York City

HAYES PUMP AND MACHINERY CO.

94 PEARL ST., BOSTON, MASS.

Pumping Plant Contractors

CENTRIFUGAL, POWER, STEAM PUMPS

STEAM TURBINES
WATER WHEELS

ELECTRIC MOTORS
OIL ENGINES

GOLDEN-ANDERSON

Patent Automatic Cushioned Controlling Altitude Valves

We have enlightened many a water user in municipalities, in industrial plants and on railroads, as to the adaptability of these Golden-Anderson Valves, and as to their function of SAVING, and of eliminating troubles.

For automatically maintaining Uniform Stage of Water in Tank, Reservoir or Standpipes. Doing away with the annoyance of Freezing and Float Fixtures inside or outside of Tanks.

"Three Ways of Closing These Valves":
1st —Automatically, by water.
2nd—By Electricity, if desired.
3rd—By Hand

May also be arranged to automatically close when a break occurs in the mains. When necessary they may be so connected as to "work both ways" on a single line of pipe. No valves or fixtures inside or outside.

Sizes to 24 in.

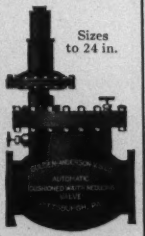
Remember!

"HOSTS OF REFERENCES"
Valves cushioned at all times by air and water
No water hammer or bursting mains

"Made with stop starter attachment for centrifugal pumps"

GOLDEN-ANDERSON
Pat. Automatic Cushioned Water Pressure Regulating Valves

1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly Cushioned by water and air. No metal-to-metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required — No attention necessary.
5. Positively no hammering or sticking.



Sizes to 24 in.

GOLDEN-ANDERSON
Patent Automatic Cushioned Controlling Float Valves

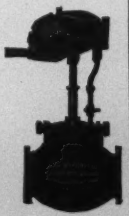
They carry a constant water level in feed water heaters by perfectly controlling the flow of makeup water.

Operated by protected enclosed copper float.

Cushioned by both air and water.

Operate without hammering, sticking or chattering. No metal-to-metal seats. Made angle or straightway.

Sizes 1 in. to 24 in.



GOLDEN-ANDERSON
Pat. Automatic Cushioned Water Float Valves

1. Automatically Maintain Uniform Water Levels in Tanks, Standpipes, etc.
2. Instantly Adjusted to Operate Quickly or Slowly.
3. Floats Swivel to any Angle — Most Satisfactory Float Valves Known.
4. No Metal-to-Metal Seats — No Water Hammer or Shock.
5. Cushioned by Water and Air.

Angle or Globe

Sizes to 24 in.

GOLDEN-ANDERSON
Patent Automatic Double Cushioned Check Valve

Sizes to 24 in. Angle or Globe

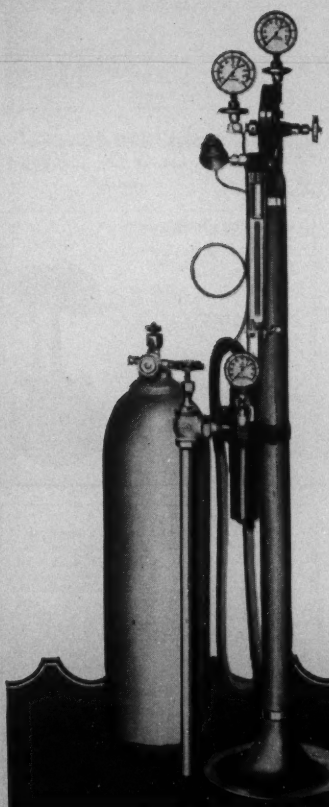
Automatically prevents reverse flow of pressure. Perfectly cushioned to prevent shock or hammer. Especially adapted for water works to prevent disastrous reverse flow of pressure due to pumps stopping. Arranged so that quick or slow operating may be obtained.

Golden-Anderson Valve Specialty Co., 1325 Fulton Bldg., Pittsburgh, Pa.

—and now

Introducing!

The New PARADON



Solution Feed Chlorinator

Six typical recent New England buyers of this new PARADON unit:

1. State Tuberculosis Commission
   Uncas-on-Thames,
   Norwich, Conn.
2. Hollingsworth & Whitney Paper Company
   Gardiner, Maine.
3. American Writing Paper Co., Inc.
   Holyoke, Mass.
4. Abington & Rockland Water Works
   Bryantville, Mass.
5. U. S. Naval Training Station
   Newport, Rhode Island.
6. Fort Ethan Allen
   Vermont.

Send for Bulletin N-28.

THE PARADON COMPANY
Arlington, New Jersey

Paradon
CHLORINATORS
for
City and Private Water and Sewage Systems, Industrial Plants and Swimming Pools

W 22 sm

Type of Eddy Hydrant Popularly Used

More Than Sixty Years of Experience Goes Into All

EDDY

Hydrants and Valves

BUILT TO MEET EVERY EXACTING REQUIREMENT OF WATER-WORKS SERVICE

Practical water-works men instantly recognize the superior features of Eddy products. For instance, with the hydrant.

A damaged valve can be replaced in a few minutes — Water hammer is avoided by the valve closing against the pressure and the use of the cut-off under the valve, which gradually closes it —
Stems cannot be bent in closing the hydrant.
Nothing can lodge on the valve seat to prevent closing of the valve —
The Drip Rod can be removed without interfering with the hydrant in any manner —
The position of the stem of the hydrant indicates accurately the position of the valve —
Whatever can pass the valve opening will pass the standpipe —
No frost case necessary —
All of these points are explained thoroughly in our catalogue, which will pay you to study.

The Eddy Valve, Too

Has its distinctive and individual features. The double disk gates are free to adjust themselves in different positions every time the valve is closed, thereby keeping smooth and tight faces. And two bronze hooks on the ball loosely engage with the gates to prevent them from spreading at the top. The center bearing gates are forced to their seats with equal pressure at all points. There is a good deal more worth knowing about Eddy Valves. Further details will be sent for the asking.

Other Eddy Products

The Eddy line of water-works products also includes horizontal and vertical check valves, foot valves, hydraulically operated valves, indicator posts, etc.
All goods made by the Eddy Valve Company are manufactured exclusively at Waterford, New York.

WRITE FOR CATALOGUE

EDDY VALVE COMPANY

WATERFORD, N. Y., U. S. A.

DONALDSON IRON CO.

MANUFACTURERS
...OF...

CAST IRON PIPE

...AND...

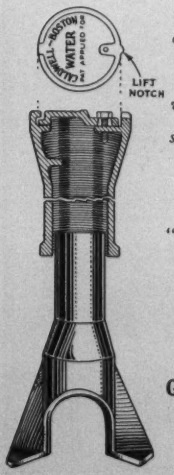
Special Castings for Water and Gas.
Also Flange Pipe and Fittings.

Boston Office:
CHARLES F. GLAVIN
24 Milk Street

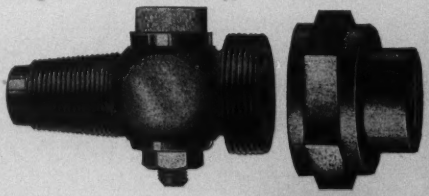
EMAUS,
LEHIGH COUNTY, PA.

The "BEST" Cast Iron Curb Box

Top section is interchangeable with the "Slide Type" Buffalo Box



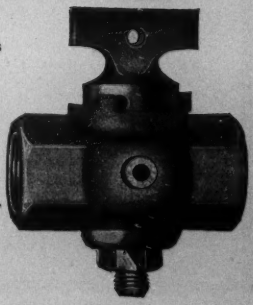
No change necessary in wrench or shut off keys



"CALDWELL" Water Works
Brass Goods, Curb and
Valve Boxes

None better and few as good

GEORGE A. CALDWELL CO.
Mattapan Square
BOSTON, MASS.



National-Boston Lead Co.

800 Albany St., Boston

Agents for

The Celebrated "ULCO"

LEAD WOOL

(Every Atom Pure Lead)

For calking pipe joints under the most difficult conditions.

For overhead joints, or in wet places where the use of molten lead is not only impracticable but dangerous — **LEAD WOOL** may be used to advantage.

It makes an absolutely tight joint which will withstand the highest pressure, yet be sufficiently elastic to allow considerable sagging or settling of the pipe without danger of a leak.

As compared with the poured joint, in this respect, the superiority of **LEAD WOOL** is apparent.

Manufacturers of

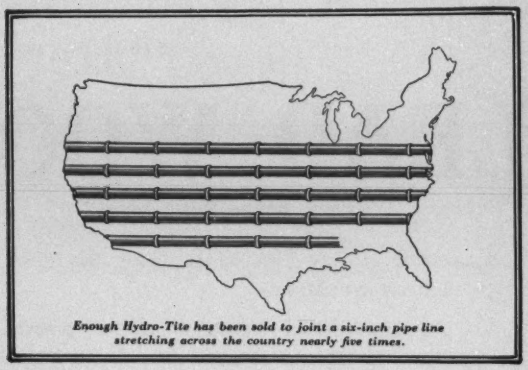
Lead Pipe, Tin Lined Lead Pipe, Pure Block-Tin Pipe, Solder, White Lead and Red Lead.

HIGHEST QUALITY SOFT BRANDS

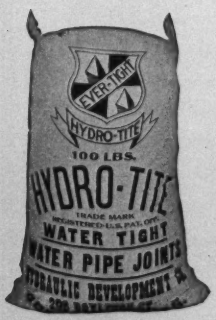
PIG LEAD

HYDRO-TITE

— *its record . . .*



Enough Hydro-Tite has been sold to joint a six-inch pipe line stretching across the country nearly five times.



HYDRO-TITE is always the same, comes in moisture proof, non-dusting bags, is shipped the day order is received. Every bag is subject to a guarantee which makes it impossible for you to lose by trying this modern pipe jointing material.

. . . over 21 years without a failure

Millions of joints in cast iron bell and spigot water pipe have been made with HYDRO-TITE.

In over 21 years not a single failure has been reported to us.

No wonder that year by year more waterworks men specify and use HYDRO-TITE and HYDRO-TITE equipment. They profit because HYDRO-TITE joints never blow out, leak 75% to 95% less than engineers specify for lead joints, withstand deflection and vibration, save 75% as compared with lead, require no caulking.

Write for the new HYDRO-TITE *data book, just issued*

Hydraulic Development Corporation

Main Sales Office:
50 Church Street, New York, N. Y.

General Offices and Works:
80 Boylston Street, Boston, Mass.

HYDRO-TITE

Reg. U.S. Pat. Off.

TODAY'S SELF-CAULKING WATER-PIPE JOINTING COMPOUND

ECONOMY is a distinctive virtue, and consists not in saving, but in selection ..... Burke

THERE ARE TWO COMMON ways to select valves and fire hydrants — on the basis of price or the basis of quality.

If price is the deciding factor, you can't expect unfailing service or extra long life. But if you buy on quality, you can expect trouble-free service for many years — which is exactly what you get from Darling Valves and Hydrants.

The selection of Darling Products is true economy. For though the initial cost may be slightly higher the ultimate cost is decidedly lower.

A request will bring full information.

Darling Valve & Mfg. Co.

Williamsport, Pa.

New York Oklahoma City Houston

DARLING

GATE VALVES & FIRE HYDRANTS

For the Cities of Today and Tomorrow

Even tax-payers notice the new Ludlow Diamond

They like it and say so. For even the most inexperienced layman can see the outstanding beauty of modern design, the added safety of self-illumination and the common sense of ground line coupling flange.

Expert technical men, trained engineers and waterworks officials see, in addition, the improved, non-flooding valve mechanism, the precision of Ludlow manufacturing standards and Ludlow's lasting economy.

A cost of less than 2 cents per unit per year for repair parts on 8,000,000 Ludlow Valves and Hydrants in 3,000 cities and towns is still further proof that tax-payers gain when their hydrant money is invested in Ludlow products.

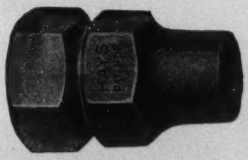
The LUDLOW VALVE MFG. CO.

TROY · · · NEW YORK

1866 First with the Gate Valve · · 1931 The new Multi-Valve

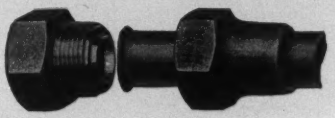
The Hays Copper Plumbing Method

Regular Corporation Stop



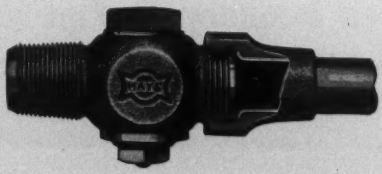
Adapter

In making an installation with Hays Copper Service Fittings the regular Corporation Stops can be used in conjunction with the adapter. It is not necessary to procure new mandrels, as the Corporation Stops are inserted with the regular mandrels, in the usual manner, after which the adapter is attached.



Open View of Adapter

These adapters are made with Female Thread for Increased I. P., Water Works Standard or Lead Flange.



To use standard Corporation Stops with Increased I. P. or Water Works Standard Thread, and where a direct connection of the Corporation Stop and Copper Pipe is desired, the above stop has been designed. (See cut above for sectional view of joint.) These stops permit a Hays 90° seal with the use of regular male mandrels.

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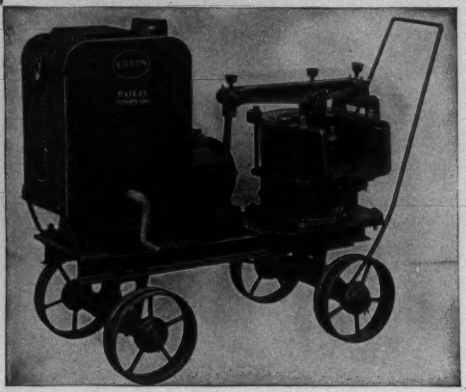

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